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# JOURNAL

*of the*

# AMERICAN WELDING SOCIETY

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### Fundamental Research

The American Bureau of Welding will, during the coming year, give special attention to the matter of Fundamental Research. To this end a committee has been appointed under the chairmanship of Mr. H. M. Hobart. Contacts have been established with several leading universities, who are cooperating with the American Bureau of Welding in making these fundamental investigations. Some of the contacts already established and the investigations being undertaken are given below.

Leland Stanford, Stanford University, California; Study of Welds Subjected to Elevated Temperatures; C. Moser.

State College of Washington, Pullman, Wash.; Fatigue Properties of Welded Joints; G. E. Thornton.

University of Toronto, Toronto, Canada; Metallurgical Studies of Welds; J. A. Newcombe.

Carnegie Institute of Technology, Pittsburgh, Pa.; Study of Effect of Heat of Welding on Adjacent Metal; V. N. Krivobok.

Catholic University, Washington, D. C.; Stresses Caused by Welding in Certain Joints; L. H. Crook.

Rensselaer Polytechnic Institute, Troy, N. Y.; Stresses Caused by Welding in Certain Joints; T. R. Lawson.

Lehigh University, Bethlehem, Pa.; Surface Tension of Molten Metal; G. Doan.

"The subject being investigated at any one university has usually been selected with reference to the facilities at that particular university or the training and inclinations of the professor having the work in charge or as the result of the receipt by that university of a request for facts not yet known."

With the assistance of a number of the Member Companies of the American Welding Society, specimens will be made up under known conditions and furnished to the laboratories in accordance with their requests. It is expected that a conference will be called in the very near future to stimulate further progress in this investigational work. This conference will be financed by contributions from several interested companies. It is expected that contacts will also be established with several other universities and specific problems assigned.

### Structural Steel Research

Another step in the progress of the work of the Structural Steel Welding Committee was recently made in the distribution of printed copies of the program of research of this committee. This program is divided in sections as follows: (A) General Information; (B) Qualification of Welders; (C) Welding Specifications for Test Specimens; (D) Inspection and Supervision; (E) Design of Test Specimens; (F) Procedure for Testing Test Specimens.

Copies of this program are now being sent to some forty leading fabricating shops throughout the country, who have indicated a willingness to participate in the work, and specific specimens are being assigned for preparation to these fabricating shops. All the welders who participate in the work of this committee must be qualified in advance.

### Fall Meeting

Considerable progress has been made in lining up a technical program for the Fall Meeting which will assure a large attendance and assist in making the Fall Meeting an outstanding success. Among the technical papers that will be presented on this occasion are: "Welding Developments in Europe, With Emphasis on Thermit Welding," by J. H. Deppeler;

"Welding in Heating, Ventilating and Plumbing Industry," by R. A. Jack; "Design and Construction of Piping System for Large Plants," by D. Adams; Formula for Computing Design Stresses for Pressure Vessels, by S. W. Muller. Welding the Aircraft Structure, by A. G. Fokker. "Design of New Types of Joints for Structural Steel Welding," by Prof. F. P. McKibben. Cutting Practices in Fabricating Shops. Welding Wire Research. "Design of Machinery Parts by Use of Welding of Steel Shapes," by Messrs. Hague, Marthens and Brinton.

## Welding Condensing Equipment

The Semet-Solvay Engineering Corporation is building and installing a new cooling, condensing and purifying equipment for the Central States Utilities Company's plant in this city.

The equipment consists of a scrubber and a welded steel purifier. The scrubber will be 3 ft. in diameter and 41 ft. high. The purifier will be of the two-compartment type, 10 ft. by 33 ft. by 12 ft. 6 in. in size. It will have a 12-in. manifold with six valves. All equipment and piping will be of welded construction.

## In Memoriam

At the annual meeting of the board of directors of the American Welding Society, held at the Engineering Societies Building, New York, N. Y., on the twenty-seventh day of April, 1928, by a vote the following tribute to the memory of

WOLCOTT REMINGTON

was unanimously adopted:

Wolcott Remington, vice-president and chief engineer of the Thomson Electric Welding Company, died at his home on March 19, 1928. He was born in Indian Territory in 1874. He studied for several years at the Massachusetts Institute of Technology with the class of 1900. During the World War he was cited and awarded the Medal of Honor by the British Government for notable achievements in the production of munitions. In the years 1922-23, as a representative of the Thomson Electric Welding Company, he was president of the National Metal Trade Association. He was one of the outstanding engineers in the design and application of electric resistance welding machinery and welded products.

Personally, Mr. Remington was quiet in speech, modest in demeanor, heartily sincere and conscientious in his work and in his private relations, but notwithstanding his modesty, was enthusiastic in the study and application of his engineering skill for the benefit of industrial progress and furtherance of the welding art. His untimely removal from the engineering field which he had chosen is quite a loss to the profession.

RESOLVED, That this tribute to the memory of Wolcott Remington be spread upon the records of the Society and a copy sent to the Thomson Electric Welding Company as an expression of our mutual loss and sympathy.

F. T. LLEWELLYN,
President.

June 26, 1928.

## Fatigue and Endurance

(*From Engineering News Record*)

*Fatigue and Corrosion.*—Among the most prominent additions to knowledge of materials brought out at the Annual Meeting of the A. S. T. M. were new data on fatigue and the closely related "corrosion fatigue" given in two papers, one by D. J. McAdam, Jr., of the Naval Engineering Experiment Station at Annapolis, and one by F. N. Speller, I. B. McCorkle and P. F. Mumma, of the National Tube Company. Dr. McAdam greatly extended and confirmed his previous inferential demonstration that the combined action of corrosion and cyclic stress produces its endurance-lowering effect by pitting, notch formation and stress concentration. He showed in particular that torsional fatigue tests produce incipient cracks of cross shape on 45-deg. axes with the length and therefore across the direction of resultant maximum tensions. By developing several new forms of diagrams for plotting the test results he brought out the relation between pitting, notching and destructive stress concentration in clear and convincing manner.

General support was given to these findings by the investigations of Speller and associates, which showed that corrosion inhibitors (as a bichromate) will raise the corrosion-fatigue limit up to the original fatigue limit; and

that special conditions which form local electrolytic concentration cells will lower the corrosion-fatigue limit even below its normal position. The results of the work may help to reduce fatigue breakage of rotary drilling pipe.

New endurance data were also brought forward by Prof. J. B. Kommers, of the University of Wisconsin, who tested cast iron in fatigue. It was found that the endurance of cast iron is roughly related to static tensile strength, to modulus of rupture and to hardness, but not to chemical composition. However, actual fatigue tests should be made to check any endurance inferences from static strength. Dr. H. W. Gillett, of the Bureau of Standards, and others suggested that with so variable a material as cast iron the plotted fatigue values require drawing a zone or belt of endurance rather than a single line; and possibly the same thing should be done for steels.

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## Standing Together

*(Taken from July 9, 1928, issue "Aviation")*

In most industries when a manufacturer meets with misfortune, his competitors take advantage of the situation in every way possible. In the aeronautical field, however, matters seem to be somewhat different. There is a certain sense of striving for a "cause," which in time of crisis makes a common bond for all those in the industry. This was recently forcibly brought out when a well-known and, incidentally, well-liked manufacturer of commercial planes had a severe accident in his plant.

Due to causes which might be termed political, public officials and newspapers in the town started an active campaign against the manufacturer. All sorts of legal methods were attempted to stop the building of the planes and serious difficulties were put in the way of the continuance of the business. However, offers of help were forthcoming from all over the country, and in spite of the rush of business in most of the other aeronautical factories many offered to help in the continuation of production. It has become obvious that the local press and politicians had taken advantage of the plant misfortune of a single manufacturer to launch an attack on the whole aeronautical industry. Under other circumstances, the attack might have been embarrassing, but the aeronautical industry had had too long a struggle against difficulties not to unite when it was unfairly attacked. The present psychology of the aeronautical industry and of the whole nation has been aroused to a sense of airmindedness, and anyone who is openly working to check the progress which is being made is bound to meet national disapprobation, not only from the members of the industry but from the general public at large.

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## Schools for Welding

*Purdue University*

A course for welders will be offered this summer by the Department of Practical Mechanics, Purdue University, for the benefit of men wishing to receive expert training in the art of welding. This course has been developed through a very close cooperation between the industries and Purdue University. It includes lectures, demonstrations and practice in oxy-acetylene and electric welding.

Instructions in the above subjects will be given by experts well qualified to teach all phases of the work.

The time required for the course is nine weeks of 40 clock hours per week, beginning June 14, 1928.

There may be opportunity for certain modification of the course to suit the needs of the individual.

*Georgia School of Technology*

The Georgia School of Technology has installed a welding laboratory in order to be able to give a course in welding as part of the regular Shop Laboratory instruction program,

Those at the head of the Shop Laboratories have long been aware of the rapidly increasing importance of the several methods of weldings and their applications in engineering work. Apparatus is available for demonstration, lectures and use of arc welding, oxy-acetylene welding and cutting, thermit and resistance welding.

Three courses have been planned and given during this first year of operation. First is the regular sixteen weeks course which is scheduled

for one three-hour period each week for a full semester. This course is required of all Sophomore students in Civil Engineering in the fall term. Sixty-seven men took this course the first term of this school year. Nine out of this number were taking the course as an elective, although it had never been offered before at the school. The sixteen week course is offered entirely as an elective course in the spring term, and is now being conducted with a class of fifteen men. An eleven week course is given to the Pre-junior Cooperative students in Mechanical Engineering. There are twenty men taking this course. Six of these are Cooperative students in Electrical Engineering, who have elected this course. For a number of years the regular Senior Electrical Engineering students have been given a course which consisted of eight weeks in forge shop and eight weeks foundry. In the spring term of this year some of these students have been allowed to substitute eight weeks in the Welding Laboratory for the eight weeks of forging. Sixteen men made the substitution.

*Denver Opportunity School*

The classes in the art of Welding at the Opportunity School have the following aims:

(1) An understanding of the welding processes and their possibilities. A thorough knowledge of the principles of physics and metallurgy involved in making a good weld. A knowledge of Metallography. A knowledge of the limitations of the processes. A knowledge of every unit of the apparatus used. Complete knowledge of all the common metals and the methods of identifying and welding each of them.

(2) Skill in handling the apparatus with confidence and proper regard for safety considerations. Ability to make minor repairs and adjustments. Ability to recognize different metals and select the right procedure for welding each of them. Ability to plan and carry out each job with the least possible expenditure of gas, current and time. Ability to secure *perfect fusion* and *thorough penetration* on *every weld.* Ability to test his own work, recognize defects and overcome them. Ability to dispose work and apparatus so as to weld with maximum comfort and efficiency.

Lecture rooms and shops are well equipped with modern apparatus and devices. Scrap material is contributed by companies in the vicinity. The average enrollment for the past five years has been around 325. Night and day classes are held.

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## EMPLOYMENT SERVICE BULLETIN

### SERVICES AVAILABLE

A-75. Welder desires position. Have had a number of years' experience, including two years with American Locomotive Company, welding and cutting. Welding for Kaustine Company, ten months. Welding for M. C. R., two years. Welding at Kellogs and Kovens, Jersey City.

A-76. Welder desires position. Have had ten years' experience in gas and arc welding in steel mills, steel foundries, repair shop, and pressure pipe welding. Am willing to go anywhere.

A-77. Welder desires position. Am capable of doing any class of welding. Would prefer foreign work.

A-78. Executive and Salesman desires position. Can organize and handle men. Desirous of making connection with a live going concern. Have had successful experience handling the sales of alloys, castings, finished products, particularly for resistance welding. Can furnish excellent reference as to ability, honesty and character. Have a wide acquaintance among executives and purchasing agents. Am 38 years of age and am married. Have a college as well as a technical education.

# Control of Stresses in Pipe Line Construction*

*By* L. T. JONES *and* W. S. WEEKS†

IT is my pleasure to present for your consideration the results of a study of pipe line stresses, results that have been accumulating for the past two years. You may remember that a year ago the University of California published the results of a study of stresses in a large welded pipe line. For a complete account of the stresses, their measurement and analysis as of that date I refer you to that publication.[1]

I shall review briefly the stresses that are encountered in the construction of a pipe line and shall point out a new method for the elimination of the most important of those stresses.

The stresses which are met in construction may be divided into the following groups:

1. Line Stress
2. Differential-Temperature Stress
3. Residual Welding Stress.

1. *Line Stress.*—It is evident that during the forenoon, under a rising temperature, several hundred feet of the pipe line will creep outward along the ditch, due to compressive line stress. The stress at the free end is zero. The line stress will be only that which is necessary to move the pipe against earth friction. During the late afternoon and evening the pipe will contract. During the process of retraction there is a tension in the line which I call line tension, and which is equal to the frictional resistance of the pipe being pulled back. When the pipe stops contracting, this tension remains in the line. As more pipe is added, this tension remains and is built permanently into the line. It is present in riveted pipe lines as well as welded ones.

It is not due to any faulty method of construction and it cannot be entirely eliminated. Its magnitude in a pipe line of large diameter may be 8000 lb. per square inch. Laying the line in groups of twenty sections each and joining the groups will reduce this stress to about half as much.

2. *Differential-Temperature Stress* is the stress due to the welding or riveting of a pipe line into a straight line at a time when there is a difference of temperature of the top and bottom of the pipe. Differential-temperature stress in large lines is frequently due to a temperature difference as large as 50 deg. Fahr. This temperature difference produces a stress of 10,000 lb. per square inch, which will exist in the top

*Abstract of paper presented before American Water Works Association.

†University of California, Berkeley, Cal.

[1] A Physical Study of the Mokelumne Pipe Line, Vol. 2, No. 9, University of California, Publications in Engineering, University Press, Berkeley, California. A report was also published in the June, 1927 issue of the Journal of the American Welding Society.

fibers when the pipe cools to uniform temperature. This stress can be eliminated by making all girth joints during those hours when top and bottom temperatures are equal. The few miles of Mokelumne Line whose girth joints were electric arc welded were made free of differential-temperature stress by welding at night. They did not break.

3. *Residual Welding Stress.*—Those of you who may have read the results of the investigation of the welding of the Mokelumne Pipe Line will remember the emphasis placed on the seriousness of residual welding stress and may also remember the dismissal of the subject with the statement that in a line properly welded residual welding stress should not

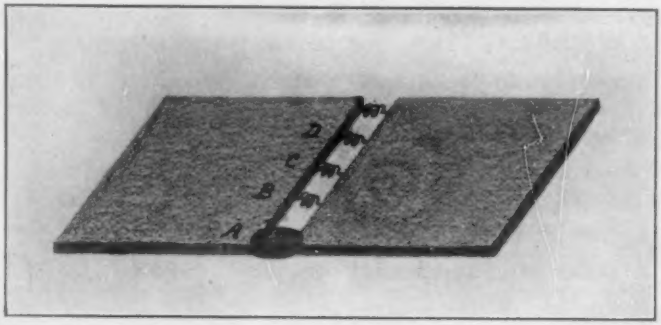



FIG. 1. THE DEFORMATION PRODUCED IN WELDING IS DUE TO EXPANSION OF THE HEATED METAL AND THE CONTRACTION, DURING SOLIDIFICATION AND COOLING

exist. By residual welding stress I mean that stress which resides in the completed piece by virtue of the fact that it was joined by welding as opposed to any other method. This stress is due to the shrinkage that occurs in steel during its solidification and cooling to normal temperature. Residual welding stress may be perhaps best illustrated by Fig. 1, which represents two steel sheets being welded edge to edge, the distance apart is exaggerated. Instead of weld metal I have indicated small coil springs joining the two edges. At the start of the weld the metal deposited at A will solidify and will then act as a fulcrum. The metal next deposited at B, C, D, etc., on cooling will produce tension to turn the two sheets about this fulcrum. Unfortunately the problem is complicated by the fact that the fulcrum continually advances.

There are three ways to produce pipe line girth welds without residual welding stress.

1. Fig. 2 shows the relief of stress that was effected on one particular joint of the 65-in. pipe line by the simultaneous heating of the whole weld. Ten acetylene torches were used to bring the whole weld to a uni- from red heat. You will notice that in some places the weld metal elongated and in some places contracted, indicating that forces of tension and compression respectively had existed. While this method has the additional advantage of controlling the crystal structure of the weld metal, I nevertheless do not believe that it is economically feasible. While it is a possible method, it must nevertheless be disregarded.

2. A second method is suggested by the discarded one, however. If it were humanly possible to produce the whole weld simultaneously or to have the whole weld hot at the same time, it would be possible to produce a weld without serious residual welding stress. Although this has been accomplished on small diameter pipe, it is not yet suitable for the construction of large lines.

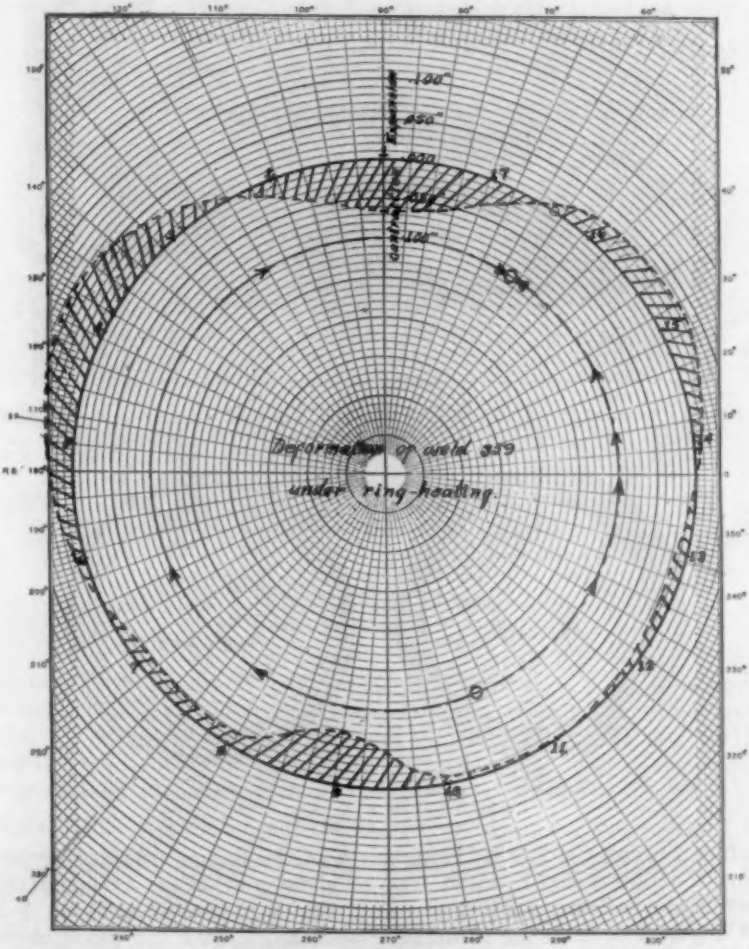



FIG. 2. RELIEF OF RESIDUAL WELDING STRESS AFFORDED BY SIMULTANEOUS HEATING OF WHOLE GIRTH WELD

3. The third method for eliminating residual welding stress was brought to my attention by H. E. Kennedy. It is a method that is new, but I say immediately that I have the utmost confidence in it. I have measured welds that have been produced in this manner and have found them to be with virtually zero residual welding stress.

Fig. 3 shows adjacent ends of two pipe sections ready to be welded. Each is provided with a narrow flange rolled at right angles to the axis of the pipe. These flanges are placed with their faces in contact and then are welded along their peripheries. The design of the flange is dependent upon the conditions of stress the completed line is to be called upon to withstand. It is happily true that in this weld the residual welding stress is nearly zero. Several types of flange weld have been tested.

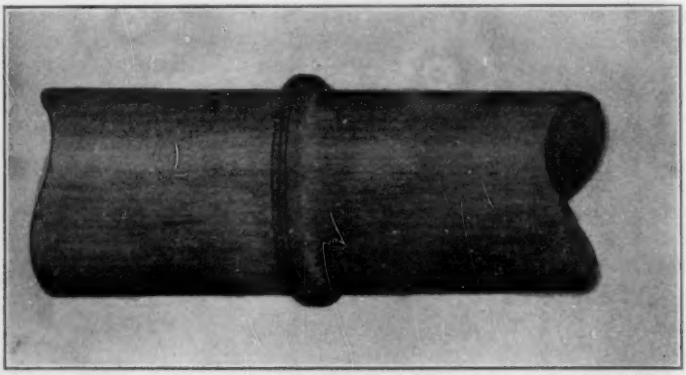


FIG. 3. PIPE SECTIONS FLANGED, READY FOR THE PERIPHERIES TO BE WELDED

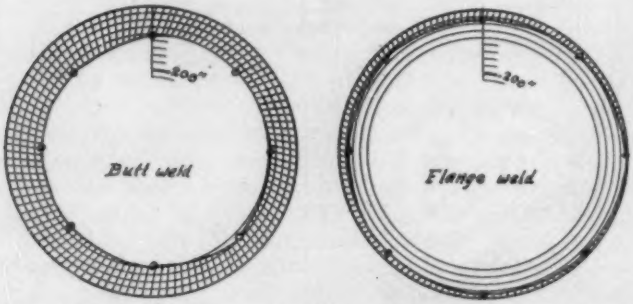



FIG. 4. COMPARATIVE DEFORMATIONS IN BUTT WELDS AND FLANGE WELDS IN 16 X ¼ IN. PIPE

Before I present a detailed comparison of the flange weld and its predecessor, the butt-weld, I would like to show you (Fig. 4) comparative values of the residual welding stress of the two types of weld on 16-in. x ¼-in. pipe. The tests on 16-in. pipe were made with the cooperation of R. S. Fuller and R. V. Wilson of the Pacific Gas and Electric Company. You will note that the deformation of the metal of the pipe proper is greater for the butt weld than for the flange weld. May I add the statement that these welds were both made by Mr. Hopkins the same day and under as nearly identical conditions as possible.

These values of deformations are not to be taken too literally. If I were to take sufficient time to present the matter clearly, I believe I could

prove to you that in these two particular welds the stress in the pipe due to the flange weld does not at any point exceed 3480 lb. per square inch, and that in one portion of the butt weld the stress is equal to the elastic limit of the parent metal. There seem to be two portions of this butt weld that are under compression, the two alternate portions being in tension.

The reasons why pipe line welds break and why they break only part way around and virtually never for the entire circumference are indeed

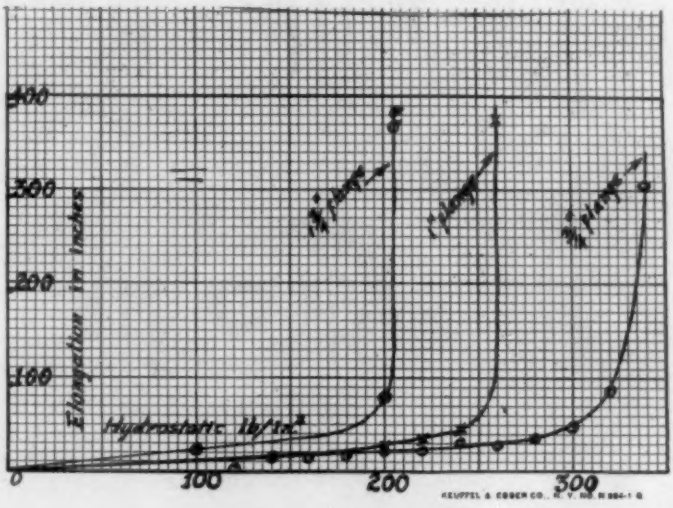



FIG. 5. WATER PRESSURE-ELONGATION TESTS ON 16-IN. PIPE TO DETERMINE THE WIDTH OF FLANGE NECESSARY TO WITHSTAND THE STRESS THE LINE IS TO UNDERGO

becoming quite clear. A detailed discussion must be postponed, however, till more time is available. In justice to butt welds may I state that this particular one is a beautiful weld and that it will never in the world fail, although the metal is severely stressed, because the weld is stronger than the parent metal.

Now, let us make a more detailed comparison of the two types of welds.

1. In the butt weld the residual welding stress is in the plane of the pipe sheet.

In the flange weld it is at the periphery of the flange and can be transmitted to the pipe sheet only by the flange.

2. The flange is designed to yield by bending long before a serious axial stress in the pipe is reached.

In tests on 16-in. x ¼-in. pipe the elongation was shown to be 0.30 in. per joint before the flange weld showed signs of distress. No buried pipe line will ever be called upon to provide so much motion in relief of stress. The stress equivalent of this 0.30 in. is 40,000 lb. per square inch.

3. The flange weld is not an expansion joint, but, rather, is an expansible joint which can permanently elongate to relieve excess stress. The butt weld cannot elongate to relieve stress.

4. The flange weld lends itself admirably to group laying. The joining of groups is less difficult than with the butt weld. It is equally easy to remove a section and replace it as occasion may demand.

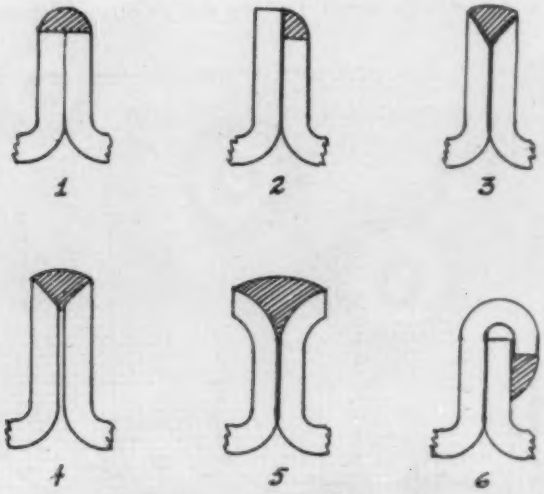



FIG. 6. TYPES OF FLANGE WELD. NO. 6 IS PARTICULARLY SUITED FOR ELECTRIC-ARC WELDING

5. The flange weld not only affords relief from residual welding stress, but also it functions to relieve line stress, Poisson stress, cold-water stress and even differential temperature stress. These four stresses the butt weld cannot relieve.

6. With the flange weld there is no accidental formation of stalactites to impede flow.

7. The relative costs of the two types of weld may be judged from the fact that for the two welds in 16-in. x ¼-in. pipe the flange weld (not including the cost of forming the flange, since it was done by hand) was less than 70 per cent of the cost of the butt weld. Including the turning of the flange by hand, it was only equal to the cost of the butt weld.

I repeat that in this weld I have the utmost confidence, and I might be accused of not telling the whole truth if I did not state that I consider it to be the most notable contribution to pipe line construction since the advent of welding.

# A Study in Welded Plate Girders

*By* FRANK P. MCKIBBEN†

A PLATE girder is a structural steel member consisting of a steel plate, called a web plate, to which other steel shapes such as angles and plates are attached along its two parallel edges to form flanges. Its function in a building or a bridge is to support loads or pressures acting transversely to its length. Briefly, a plate girder is a steel beam composed of a web and two flanges. Until recently, riveting was the sole means of connecting the flanges to the webs, but now welding is beginning to supersede riveting.

As the design of welded plate girders differs somewhat from that of usual riveted forms, the complete calculation for a typical welded girder is here presented together with a comparison between the weights of several welded and riveted types.

The problem succinctly stated is: Design an electrically welded girder, of 40-ft. span, to be supported at its ends, and to carry a uniformly distributed load of 4000 lb. per linear foot including the girder itself; and compare the result with riveted girders performing a similar function.

The following assumptions are permissible:
Shear on gross area of web, 10,000 lb. per sq. in.
Tension in flanges, 16,000 lb. per sq. in.
Compression flange assumed to be braced laterally.

Shear on welded fillet, 9000 lb. per sq. in. of limiting section. The permissible shearing values of fillets shown in Table I are based on this safe shearing strength of 9000 lb. per sq. in., which is a very conservative value. For structures where capable welders and good inspection are employed, this value can safely be taken at 11,200 lb. per sq. in., giving for a $\frac{3}{8}$-in. by $\frac{3}{8}$-in. triangular fillet a working unit stress of 3000 lb. per linear inch of fillet.

Rivets, $\frac{3}{4}$-in. diameter, with shear and bearing at 12,000 and 24,000 lb. per sq. in. respectively.

Girder design is controlled by strength or deflection or both. In what follows it is assumed that only strength need be considered.

*Welded Plate Girder*

Design No. 4 (Figs. 1 and 2)

*Item A*

End shear $= 4000 \times 20 = 80{,}000$ lb.

Required gross area of web $= \dfrac{80{,}000}{10{,}000} = 8$ sq. in.

A web 42 in. by $\frac{1}{4}$ in. meets this requirement but on account of web buckling use 42 in. by 5/16 in.

†Consulting Engineer, Black Gap, Pennsylvania.

*Item B*

The horizontal distance between web stiffeners is given by the formula

$$d = \frac{t}{40}\left(12{,}000 - \frac{V}{A}\right) = 5/16 \times 1/40 \times \left(12{,}000 - \frac{80{,}000}{13.1}\right) = 46 \text{ in.}$$

where d = distance in inches between stiffeners.

t = thickness of web.
V = vertical shearing force at section.
A = gross cross-sectional area of web.

As the value of d from this equation exceeds the web depth of 42 in., the latter will be used as the approximate horizontal distance between stiffeners.

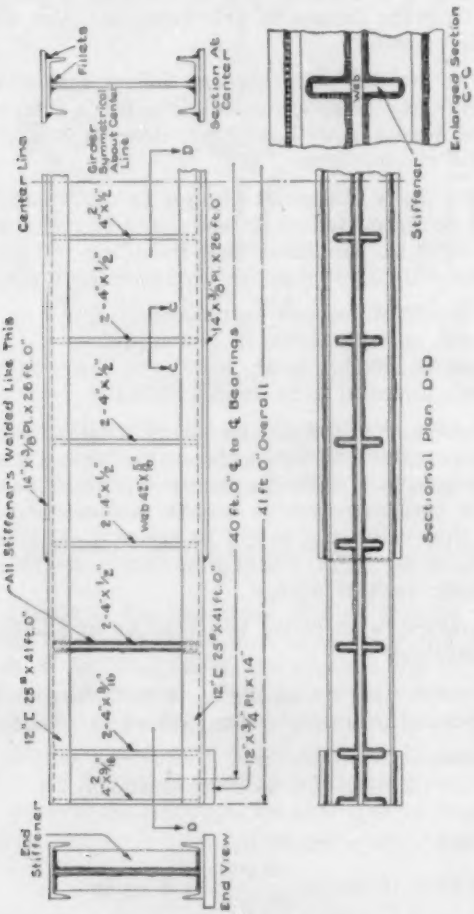



FIG. 1. ONE-HALF OF WELDED GIRDER DESIGNED TO CARRY 4000 POUNDS PER LINEAR FOOT WITH A SPAN OF 40 FT. 0 IN. CENTER TO CENTER OF BEARINGS; DESIGN NO. 4 NOTE THAT 5/16-IN. BY 5/16-IN. CONTINUOUS FILLETS ARE USED IN PLACE OF INTERMITTENT FILLETS DETERMINED BY THE CALCULATIONS

*Item C*

The cross-sectional area of the tension flange at the center of the span is:

$$\text{Net area} = \frac{M}{h'S} - 1/6\text{th}$$

where M = bending moment at center of span.

h′ = effective depth.
S = allowable unit tension.
t = web thickness.
h = web depth.

(Note that in this case the effective depth h′ and depth of web, h, are practically the same.)

$$\text{Net area} = \frac{9{,}600{,}000}{42 \times 16{,}000} - 1/6 \times 5/16 \times 42 = 12.08 \text{ sq. in.}$$

One 12-in. channel (25 lb.) = 7.35 sq. in.
One 14-in. by ⅜-in. plate = 5.25 sq. in.

Total = 12.60 sq. in.

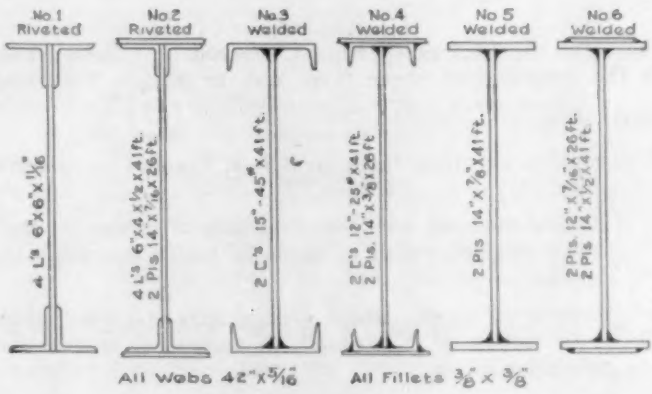



FIG. 2. CENTRAL SECTIONS OF GIRDERS, NOS. 1 TO 6 INCLUSIVE

*Item D*

As the girder is loaded uniformly, the curve of moments is parabolic; hence, one-half length of the 14-in. by ⅜-in. plate equals:

$$\sqrt{\frac{5.25 \times (20)^2}{14.78}} = 12.0 \text{ ft.}$$

Make the plate 26.0 ft. long.

*Item E*

Since the compression flange is supported laterally it will be made like the tension flange. However, if the ⅜-in. cover plate on the compression flange be welded only along the channel flanges, the distance between these welds would be 12 in. or 32 times the thickness of the cover plate. As

the maximum edge distance usually allowable is only eight times the plate thickness, the design as shown is not ideal. This difficulty could be overcome by punching two rows of holes in the compression plate and plugging these with weld material, thus connecting the plate to the channel. However, since the distance in question is an internal and not an edge distance, the design shown is considered adequate.

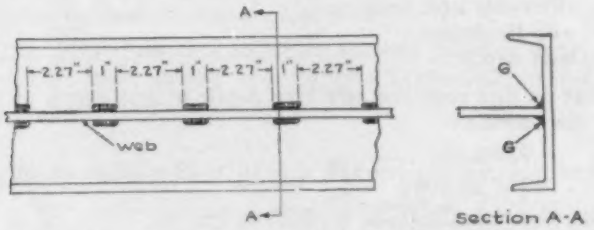



FIG. 3. PLAN OF LOWER FLANGE SHOWING REQUIRED SPACING FOR ⅝-IN. FILLETS, CONNECTING WEB AND FLANGE AT ENDS OF GIRDER; DESIGN NO. 4

*Item F*

To determine the fillet at G, Fig. 3, proceed as follows: These fillets transmit the longitudinal shear from web to flange. This longitudinal (horizontal) shear $= \frac{VQ}{I}$

where V = vertical shearing force on web at the section under consideration.

Q = statical moment, about neutral axis of girder, of that part of flange section outside of plane on which longitudinal shear is desired.

I = moment of inertia, about neutral axis of girder, of the entire cross section of web and both flanges at section under consideration.

Thus at end of girder:

$V = 4000 \times 20 = 80{,}000$ lb.

Q = statical moment of one channel $= 7.35\ (21.53) - 0.68) = 153.$

I = moment of inertia of web and two channels

| | |
|---|---|
| $1/12 \times 5/16 \times 42^3$ | $= 1929$ |
| $2\ [7.35\ (21.53 - 0.68)^2 + 4.5]$ | $= 6409$ |
| | $I = 8338$ |

$\frac{VQ}{I} = \frac{80{,}000 \times 153}{8338} = 1470$ lb. per linear inch on two fillets marked G in Fig. 3, or 735 lb. for each.

From Table I the shearing strength of one ⅜-in. by ⅜-in. fillet per

linear inch is 2400 lb., therefore the spacing required for these fillets at the end of the girder is:

$$\frac{2400}{735} = 3.27 \text{ in. arranged as in Fig. 3.}$$

While Fig. 3 shows fillets only one inch long as illustrating the results of these calculations, the writer's experience with welding in shops shows that with one-inch fillets, i.e., one inch in length, the crater remaining at

TABLE I

Safe Permissible Shearing Values of Fillets for Use in Design

| *A* (Inches) (Fig. 5) | *B* (Inches) (Fig. 5) | *X* (Inches) (Fig. 5) | Safe Strengths Per Linear Inch of Fillet at 9,000 Lb. Per Sq. In. on Section X (Pounds) |
|---|---|---|---|
| ½ | ½ | 0.355 | 3,200 |
| ⅜ | ½ | 0.300 | 2,700 |
| ⅜ | ⅜ | 0.266 | 2,400 |
| ¼ | ⅜ | 0.208 | 1,870 |
| ¼ | ¼ | 0.177 | 1,600 |

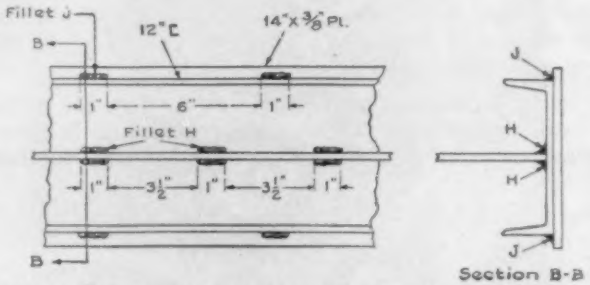



FIG. 4. PLAN OF LOWER FLANGE SHOWING REQUIRED SPACING FOR ⅜-IN. FILLETS, CONNECTING WEB AND CHANNEL, ALSO CHANNEL WITH 14-IN. PLATE; DESIGN NO. 4

the end of each fillet forms too great a proportion of the short weld. If fillets two inches long were used, the computations would give $\frac{2400 \times 2}{735}$ = 6.5 in. This requires fillets 2 in. long alternating with open spaces 4½ in. long. However, continuous fillets are recommended for this girder as shown in Fig. 1.

*Item G*

Fillets H and J, Fig. 4, at a point 13 ft. from the center of the span where the 14-in. by ⅜-in. cover plate ends are obtained in a similar manner.

Thus:

For fillet H, Fig. 4

$V = 4000 \times 13 = 52{,}000$ lb.

$Q = 7.35\ (21.53 - 0.68) + 5.25 \times 21.72 = 153 + 114 = 267$

$I = 8338 + 2\ [5.25 \times 21.72^2] = 13{,}308$

$$\frac{VQ}{I} = \frac{52{,}000 \times 267}{13{,}308} = 1040 \text{ for two fillets H or 520 lb. for one fillet.}$$

Pitch of ⅜-in. by ⅜-in. fillets one inch long $= \frac{2400}{520} = 4\frac{1}{2}$-in.

(See Fig. 4).

For fillet J, Fig. 4

$\frac{VQ}{I} = \frac{52{,}000 \times 114}{13{,}308} = 450$ lb. per linear inch for two beads or 225 lb. for one. But as the spacing for intermittent welds required for beads J to connect the 14-in. by ⅜-in. cover plate to the channel is $\frac{2400}{225} = 10.6$ in., a distance so great as to afford insufficient protection against buckling of the ⅜-in. cover plate on the compression flange, these fillets J will be made not to exceed 16 times the thickness or 6 in., as shown in Fig. 4.

*Item H*

End stiffeners over the bearings may be of four L's 4 in. by 3 in. by 9/16 in. for riveted, or four flats 4 in. by 9/16 in. for welded girders, designed as follows. On account of unequal bearing resulting from the girder's deflection let us assume that three-quarters of the end reaction is carried by each pair of bearing stiffeners., i.e., ½ × ¾ × 80,000 = 30,000 lb. per stiffener.

In thirty years' experience with steel construction, the writer has observed only two cases where stiffeners were weak and in both instances the angle failed by buckling in the outstanding leg near the bottom.

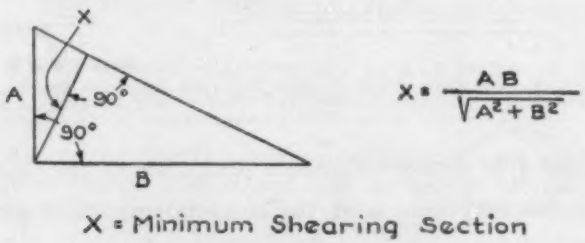



FIG. 5. CROSS-SECTION OF TRIANGULAR FILLET

Each stiffener will therefore be designed as a column 8 in. long and only the outstanding leg will be assumed to carry the load of 30,000 lb.

For a 4-in. by 9/16-in. section the radius of gyration squared about central axis parallel to longer side is:

$$\frac{1/12 \times 4 \times (9/16)^3}{4 \times 9/16} = \frac{27}{1024}$$

and the average permissible unit compression is:

$$\frac{16{,}000}{1 + \frac{8^2}{20{,}000\left(\frac{27}{1024}\right)}} = 14{,}300 \text{ lb. per sq. in.}$$

The average actual unit compression $= \frac{30{,}000}{4 \times (9/16)} = 13{,}300$ lb. per sq. in.

The 4-in. by 9/16-in. flat bars or 4-in. by 3-in. by 9/16-in. L's are satisfactory; the former for use on welded and the latter on the riveted girders.

Fig. 6. Half-Through Riveted Plate Girder of Railroad Bridge

*Item J*

The length of $\frac{3}{8}$-in. by $\frac{3}{8}$-in. fillets required to transmit end shear from each end stiffener into the web is $\frac{30{,}000}{2400} = 12\frac{1}{2}$ in.

In Fig. 1, which shows the welded girder, these fillets are extended from bottom to top flange. Continuous, not intermittent welding, has been used throughout even though calculations show the latter to be of sufficient strength. The continuous fillet is more desirable, particularly

in the top flange; and it costs little if any more than the intermittent, especially if automatic welding machines be used for the continuous fillets. But if intermittent fillets be used, a minimum length of two inches exclusive of the crater is a desirable practical limitation.

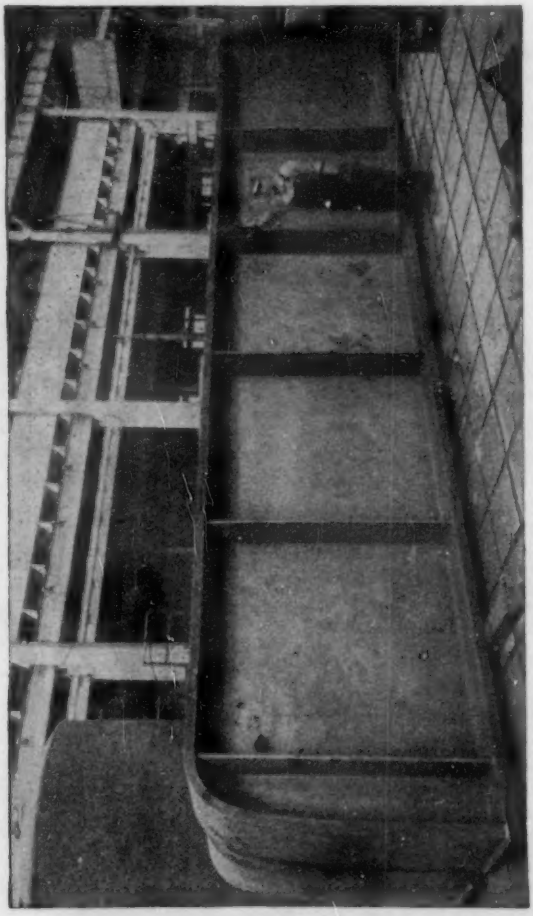


FIG. 7. FABRICATED WELDED GIRDERS FOR UPPER BEARING BRACKET OF 19,000-KV-A. WATERWHEEL GENERATOR

*Comparison of Weights*

To compare the weights of welded and riveted girders Table II is presented, showing that a saving of 27.1 per cent in weight of steel results by using welded girder No. 6 instead of riveted girder No. 1, i.e., 27.1 per cent of the riveted girder. But this is not quite a fair comparison because the riveted girder No. 1 has flange angles only, which extend the entire length, whereas in welded girder No. 6 weight has been minimized by cutting off the flange plates to conform with the parabolic moment curve. On the other hand, the riveted girder No. 1 is a type in very com-

mon use and the comparison presented is justifiable. Another, and more equitable comparison, is furnished by riveted girder No. 2 and welded girder No. 6, as each has the outer flange plates cut to meet the moment requirements. A saving of 6455 — 5467 = 988 lb. or 15.2 per cent is shown for the welded girder No. 6, i.e., 15.2 per cent of the riveted girder.

TABLE II

Comparison of Weights of Riveted and Welded Girders

| Design No. | Weight (Pounds) | Pounds Saved Over No. 1 | Per Cent of No. 1 Saved | Remarks |
|---|---|---|---|---|
| 1 | 7,498 | .... | .... | Riveted |
| 2 | 6,455 | 1,043 | 13.9 | Riveted |
| 3 | 6,282 | 1,216 | 16.3 | Welded |
| 4 | 5,572 | 1,926 | 25.7 | Welded |
| 5 | 6,012 | 1,486 | 19.8 | Welded |
| 6 | 5,467 | 2,031 | 27.1 | Welded |

TABLE III

Weight of Welded Girder, No. 4

| Section | Expression | Weight (Lb.) | Remarks |
|---|---|---|---|
| 2 Channels 12 in. (25 lb.) by 41 ft. 0 in. | 2×25×41 | 2050 | Flange |
| 2 Plates 14 in. by ⅜ in. by 26 ft. 0 in. | 2×17.85×26 | 939 | Flange |
| 1 Plate 42 in. by 5/16 in. by 41 ft. 0 in. | 44.63×41 | 1830 | Web |
| 8 Flats 4 in. by 9/16 in. by 3 ft. 6 in. | 8×7.68×3.5 | 214 | End Stiffeners |
| 20 Flats 4 in. by ½ in. by 3 ft. 6 in. | 20×6.8×3.5 | 476 | Intermediate Stiffeners |
| 2 Plates 12 in. by ¾ in. by 1 ft. 2 in. | 2×30.6×1.17 | 72 | Bearing Plates |
| | | 5572 | |

A more precise comparison of weights would take cognizance of rivet heads and punchings from plates and angles on the one hand, with weights of welding electrodes consumed on the other.

For the sake of completeness, the weight calculations for the welded girder No. 4 are given in Table III. Other weights are similarly computed.

*Conclusions*

A study of the results obtained reveals that the saving in weight of welded girders is due to the following factors:

(1) Elimination of all loose fillers.
(2) Use of flat bars instead of angles for stiffeners, thus eliminating the metal in angle legs in contact with the web.
(3) Elimination of rivet holes in tension flanges, because gross areas are used in the welded designs and net areas in the riveted.
(4) Inasmuch as the "web equivalent" in welded girders is one-sixth the web area, while in riveted girders it is only one-eighth, smaller flanges are permissible in welded types.

Thus, based on savings in weight alone, welded girders have great possibilities.

# Spot Welding*

*By* G. A. HUGHES†

TO the average man "electric welding" means arc welding. It will be a surprise to many to learn that resistance welding is more generally used in the manufacture of the articles we use every day than all other methods of welding combined. Its use extends from the welding of the stems on the watches in our pockets, the frames of our eye glasses, the handles on knives and forks, the rims and frames of baby carriages and our automobiles, rims for truck wheels, and even rims for passenger locomotives.

*Spot Welding*

Spot welding of overlapping metal plates or sheets is as the name indicates. Is simply welding in spots at intervals. The principle of spot welding by the resistance method (and likewise in butt welding) consists in passing an alternating current of high amperage and low voltage through metals at point of contact, and when the metal is in a molten state, pressure is applied to force the metal together. The theory is that in a series circuit, heat is produced in proportion to the resistance of any particular portion of the circuit. Now, if the conductors leading from the source of supply of current be of low resistance and a piece of metal be inserted, the heat produced will be at point of contact. This is an ideal condition for spot welding.

The resistance between copper contact (Fig. 1) electrode (b) and work (w) and electrode (a) and work (w) is less than that between work (w) and (w'). As a result of this, the greatest heat is produced at point K, just where it is needed. When the metal in contact with the electrode (b) is in a plastic state (just before fusing), added pressure on (b) forces the molten metals together and makes a weld at K. This is actually what happens in the making of a spot weld, whether on an automatic, semi-automatic or manual operated machine.

Metals of low resistance cannot readily be spot welded by using copper contact electrodes as explained in welding steel or any metal of high resistance. Such metals must be heated rapidly to keep the heat from being radiated from point where weld is desired.

Since the only resistance to flow of current is at point of contact of welding electrodes and at point K in work to be welded and is insufficient for rapid heating, resistance must be introduced in the circuit. This is accomplished by using an electrode of high resistance. A very successful alloy (tungsten and copper) for this class of work is called Elkonite.

Most of the low resistance metals in thin sheets can be welded with a

*Presented at meeting of Pittsburgh Section, A.W.S., March 28, 1928.

†Electrical Engineer, Truscon Steel Co., Youngstown, Pa.

fair degree of success by using a copper electrode tipped with steel of a very high percentage of tungsten.

*Approximate Size and Shape of Electrodes*

Gages:—

30 to 22—3/16 in. Diameter Electrodes
22 to 16—¼ in. Diameter Electrodes
16 to 6—⅜ in. Diameter Electrodes
6 to 0—½ in. Diameter Electrodes

The shape electrode to use will depend on the metal and shape of the work to be welded. To determine the proper electrode to use in welding

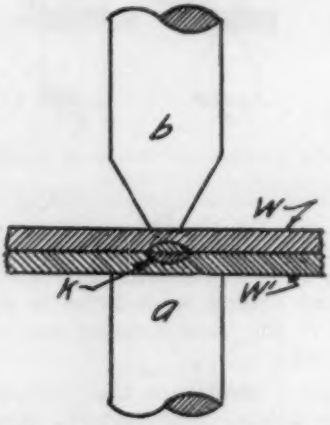



FIG. 1. CORRECT TYPE OF CONTACT

material from No. 20 gage to No. 12 gage sheet steel, a test was made by taking two machines doing the same class of work, one machine being fitted with contact electrodes as shown in Fig. 2A. The other machine was equipped with contact electrodes as shown in 2B. At the end of one month's run the saving in contact electrodes on the machine using the electrodes shown in Fig. 2A was over 50 per cent, owing to the time saved in dressing points of the electrodes. The welds made were satisfactory. These points are only good between the limits of the gages mentioned. For heavier plates, both electrodes must be pointed.

*Projection Welding*

In Projection Welding (Fig. 3) projections are formed in the work to localize the flow of current at point where weld is desired. Electrodes covering several projections are used, and the process is the same as spot welding.

*Percussion Welding*

Percussion welding is a process of welding by means of a sudden discharge of electrical energy at junction where weld is to be effected. The discharge is obtained from a condenser or a coil with suitable inductance. The weld is effected in about .005 sec.

*Button Welding*

Button method of welding consists of two large flat electrodes, as in spot welding. A button or slug is placed between one electrode and the work. As the work is brought to point of fusion, pressure is applied forcing the button in the work.

The U. S. Bureau of Standards tested this form of welding in their study of Spot Welded Structural Steel Experiments.

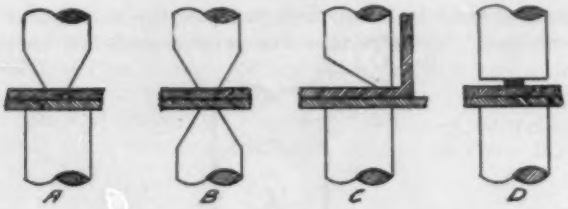



FIG. 2. CONTACT ELECTRODE SHAPES

*Multiple Welding*

When several welds are required in a piece of work as welding a strip or an angle to another strip, angle or sheet, a special transformer having a common primary and several secondaries is used. As many as ten welds are thus made in the same time as one weld. It is extensively used in sheet metal work.

In all the spot welding mentioned the welding current is controlled in the primary of the welding transformer. And the cycle of welding is setting the welding electrodes (which is in the Secondary circuit of the welding transformer) firmly on the work and closing the switch in the primary circuit of welding transformer.

There is another method of spot welding for light sheets. The work is laid on one electrode of the secondary of welding transformer. The other electrode the operator holds in his hands is connected to transformer secondary by a flexible lead.

The operator makes a weld by using this electrode as a battering ram striking the work.

A slight variation of this scheme the operator uses the electrode in the manner of a pinch bar. During the cycle of welding the current is not broken in the primary of welding transformer.

*Seam Welding*

Seam welding consists of a series of spot welds overlapping thus making a continuous weld. In light work the material is rolled between roles and current is not interrupted during the entire length of seam.

*Riveting versus Spot Welding*

The question now arises, as to what thickness of plates are practical to weld? To decide whether it is better to rivet or spot weld an article

one must take into consideration the use of the article. Sufficient welds can be inserted to obtain maximum strength of the metal welded. It is preferable for all work in which a smooth surface is desired, or where the stock will not permit the punching or countersinking of a rivet hole, in fact one is safe to say that spot welding can replace 90 per cent of the light work now being done.

While spot welding is more commonly used for welding sheets or light plates, experimental machines have been made which are able to weld plates of over 3 inches in thickness and exert a pressure of about 40 tons. The current flowing through the weld is over 100,000 amperes.

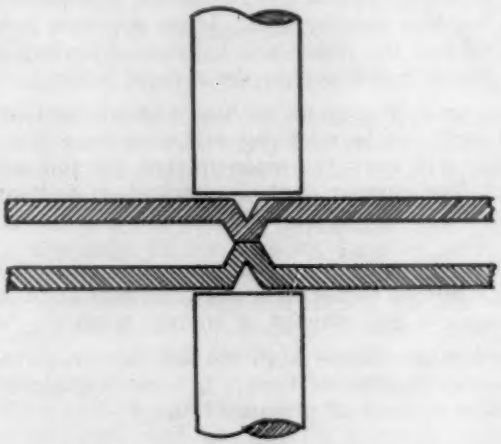


FIG. 3. PROJECTION WELDING

The question is often raised, Does different thickness of material affect the welding? It does not. A 30 ga. sheet of steel can be welded to a plate 1 in. thick. The writer has welded 30, 28, 26, 24, 22, 20, 18, 16, 14 ga. together in a bundle at one time. The weld was good. The thickness of material one can spot weld will depend on the size and shape, together with the welder.

It is interesting to know what metals can be spot or butt welded.

By some one of the resistance welding processes nearly all metals and alloys can now be welded.

Aluminum, brass, copper, lead, zinc and tin possess almost no strength when heated to the welding temperature, and therefore require delicate control of heat and pressure. Copper can be welded to steel, brass to steel and copper to brass with difficulty. Lead pipes are now being butt welded. Aluminum can be welded by percussion method. If mixed with steel or zinc the alloy is readily welded.

Galvanized iron can be welded, but in most cases the galvanizing will be burned at point of weld. German silver and monel metal can be welded if heated rapidly. High speed steel can be welded to low carbon steel. Duralumin can also be welded.

There are many variables entering in the making of a weld, as for example, the resistance of material to the flow of current, the pressure exerted on electrodes during heating period, amount of current flowing and voltage across welding electrodes.

The heat generated depends upon the amount of current flowing and the resistance of the circuit. The resistance will vary with the pressure. Rust scale, etc., cause burning of sheet at point of contact of the electrode which often has the appearance of a welding heat while still not at a welding heat at point of contact between the sheets, resulting in a poor weld.

If too much pressure is used, the resistance is lowered and the sheets are slow in heating to a welding heat. If the pressure is too light sparks will be thrown off and the welds will be poor. This can be remedied by increasing the pressure or lowering the current value.

When rust or scale is present on heavy sheets and pressure used is correct, a good weld can be made by first switching the current on for an instant. This will burn the scale or rust off and seat the contacts firmly on sheet. The current is then switched on and work brought up to a welding heat.

*Pressure*

The pressure required varies with the thickness of the work, chemical properties of material and amount of current used.

Owing to its low resistance high carbon steel requires a very light pressure and heavy current to heat. In some instances the steel will not heat if a great amount of pressure is used.

*Electrical Characteristics of the Welder*

In a single spot welder with a deep throat such as a standard manual operated welder, the conductors carry the heavy welding current parallel to the iron which, of course, increases the inductive reactance. As the current is passed through the sheet or work being welded, a choking effect is produced depending upon the distance the sheet is inserted in the throat of the machine. This is very noticeable in welding a seam of a cylinder. The greater the number of square inches of iron inclosed in the welding circuit the greater will be the reactance. This is what causes the poor power factor of a spot welder. This power factor can be improved if two spots are made at the same time. This is accomplished by using two transformers with primaries in parallel and secondaries in series. The secondary leads are shortened and placed on the same side of the work outside the magnetic loop, also the number of square inches of iron in the welding circuit are cut to a minimum.

The power factor on single spot machines will depend upon the work and somewhat on the design of machine, ranging from 0.35 to 0.50 while on two spots welders will be from 0.58 to 0.84. The power used in K. W. for making single spot welds on two pieces of 3-16 in. plates will vary of course with the time, and will be usually from 20 to 30 K. W. with a power factor which will vary with work usually between 0.35 to 0.50 (time from 10 to 15 sec.), making a ⅜ in. diameter spot. Pressure at

electrodes used to heat material at about 50 lb. per square inch pressure to force material together 700 lb. Current in weld approximately 8,000 amperes.

An integrating watt hour meter was installed on an automatic spot welder welding two pieces of 16 ga. to 14 ga. to determine amount of K. W. H. consumed per weld; size of spots about ½ in. x 3-16 in. In a day's run of 10 hr. a little more than 18,000 spots were made with a total of 389 K. W. H. consumed.

The accuracy of integrating watt hour meters recording the power consumed by welders have been questioned by many engineers, giving for their reason that, for the short period involved, the integrating watt meter is sluggish and will not respond quickly enough. On the other hand, other engineers claim that the deceleration of the meter disk will compensate for the slow acceleration of the meter disk.

The size of power transformers for a welder load is a very important one. Experience has shown that where more than one machine is used it is not necessary to install transformers whose K. V. A. rating is equal to the total K. V. A. rating of the welders. The load will vary from a fraction of a second to a few seconds depending upon the nature of the work, giving a diversity factor between total maximum load of the group of welders and the total rated capacity of the welders. To determine this factor, a series of tests run on six circuits carrying only a welder load. The total K. V. A. of three welders on a circuit working on light stock but large and difficult to handle, was over 90 K. V. A., while the average high K. V. A. consumed was 41, giving a factor of 45.5 per cent. Another circuit carrying two welders, one being semi-automatic with a total rated K. V. A. of 110, working on heavy stock but easily handled, showed an average high load of 73 K. V. A. or giving a factor of 66.3 per cent.

Another circuit having six welders with a total of 190 K. V. A. all of which were working on light stock and easily handled showed an average high load of 107 K. V. A. showing a factor of 56.4.

These tests show that where several welders are installed the transformer K. V. A. capacity should be about 66 per cent of the total rated K. V. A. of the welders.

The first spot welding in the structural steel field was by the Truscon Steel Co. in March, 1915, when they built a box column from channels using spotwelding, instead of rivets for their standard steel buildings. They were the pioneers in using spot welding for their roof trusses and floor joists. These have stood the tests for over thirteen years, and now their strength and reliability is unquestioned.

Several years ago the Bureau of Standards made quite elaborate tests on spot welded girders and columns, using the button type of spot welding and tested them with riveted girders and columns. The conclusion drawn from these tests shows practically the same strength with a little (if any) in favor of spot welds.

Some tests were made to see what effect spot welding had on the chemical analysis of sheet.

| SPECIMEN | | CURRENT | | | WELD | | | FAILURE | | LOAD AT FAILURE | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MARK | TYPE | K.W. CONS'D | POWER FACTOR | WELDING CURRENT | TIME OF | SIZE OF | COND. OF | IN WELD | IN PLATE | MAX. | MIN. | AVERAGE |
| A | 16 GA. / 16 GA. | 18.35 | 31.62 | — | 3.15 SEC. | 3/8" | BURNED | — | 2 | 4800 | 4765 | 4782 |
| B | 14 GA. / 14 GA. | 20.30 | 34.00 | 9000 | 3.00 | 5/16" | FAIR-VOID | 2 | — | 8815 | 6550 | 7682 |
| C | 14 GA. / 3/16" | 20.67 | 36.00 | 8600 | 3.15 | 3/8" | GOOD | — | 2 | 9520 | 6990 | 8255 |
| D | 14 GA. / 14 GA. 3/16" | 19.62 | 35.00 | 8300 | 3.45 | 1/2" | GOOD | — | 2 | 20190 | 18350 | 19270 |
| E | 16 GA. / 3/16" | 20.25 | 36.25 | 8650 | 3.45 | 3/8" | SLIGHTLY BURNED | — | 2 | 7330 | 7240 | 7285 |
| F | 16 GA. / 16 GA. 3/16" | 20.00 | 35.33 | 8500 | 4.65 | 3/8" | GOOD | — | 3 | 20120 | 14750 | 17273 |
| G | 3/16" / 3/16" 3/16" | 23.50 | 45.75 | 7660 | 6.84 | 1/4" TO 1/2" | VOIDS-BURNED | 6 | — | 21790 | 12325 | 17057 |
| H | 14 GA. / 14 GA. 14 GA. | 19.75 | 35.00 | 8550 | 4.22 | 1/2" | GOOD | — | 2 | 16225 | 9340 | 12782 |
| I | 16 GA. / 16 GA. 16 GA. | 15.50 | 42.00 | 7200 | 3.15 | 3/8" | BURNED | — | 2 | 10140 | 8490 | 9315 |
| J | 3-16 GA. / 3/16" | 21.75 | 40.10 | 8412 | 3.97 | 3/8" TO 1/2" | GOOD | 4 | — | 13675 | 11495 | 12440 |
| K | 3/16" / 3/16" | 22.60 | 41.00 | 8200 | 4.35 | 3/8" | FAIR-SLIGHT VOIDS | 4 | — | 11900 | 8950 | 10450 |
| L | 14 GA. / 14 GA. | 10.40 | 33.00 | 6700 | 4.75 | 1/4" | POOR | 1 | — | — | — | 4360 |
| M | 14 GA. / 14 GA. 14 GA. | 12.75 | 35.00 | 7100 | 5.40 | 1/4" | GOOD BUT TOO SMALL | 1 | — | — | — | 11350 |
| N | 14 GA. 16 GA. / 14 GA. 16 GA. 3/16" | 21.00 | 39.00 | 8200 | 5.15 | 3/8" TO 1/2" | VOIDS | 2 | — | 26135 | 23190 | 24864 |

FIG. 4. TESTS OF SPOT WELDED SPECIMENS

A piece of plate was cut and spot welded together, and sent to the chemical laboratory for analysis. The following report was received:

1.—From center of weld: Sul., 0.038, Phos. 0.020, Mang., 0.59, carbon, 0.08.
2.—From edge of unwelded section but affected by heat: Sul., 0.042; Phos., 0.019; Mang., 0.60, carbon, 0.08.
3.—From plate unaffected by heat: Sul., 0.040; Phos., 0.021; Mang., 0.58; carbon, 0.08.

In an effort to determine the safe load of a spot weld, elaborate tests were made. Over 1000 pieces of various gauges were welded having from one to three spots. Two hundred pieces were sent to Carnegie Tech. at Pittsburgh, these tests were for shear and pulled at ⅛ in. per minute. The report is too long to give in detail here. It was found that the welds varied from 6595 lb. minimum per spot to 9850 lb. maximum for 14 gal. using a 5-16 in. electrode. A careful study was made of the nature of failure of the welds and more tests made and data taken to discover just why this variation. In all cases the failure was in the weld being pulled from the sheet.

The peripheries of the welds were nearly the same but the thickness of spot varied. This, no doubt, was caused by having some spots heated to a higher degree of temperature and more metal was forced out when the pressure was applied at finish of weld. The periphery of weld multiplied by the thickness of spot gave a difference of metal to be sheared at failure of weld. This difference of metal in fraction of a square inch was the cause of variation in pounds of failure of welds.

Elaborate tests were then made to determine the relation of shearing of a spot weld to the shear of the parent metal. This was found to be 93 per cent. The relation of tensile strength to tensile strength of parent metal of steel was also 93 per cent.

In all cases in sheet metal work where the area of a spot weld is larger in square inches than the area in square inches of periphery multiplied by the thickness of the weld, the weld will pull out of sheet, where the area of weld is less—the weld will shear. In plates where spots are too small in diameter the weld will, of course, shear. When welds are of proper diameter, the weld will pull from plate and will be in the form of a cone.

In conclusion, I wish to state that spot welding is past its experimental state and has its place in industry. It has come to stay, and will soon take its place where it rightfully belongs in the structural field in larger structures.

# How to Weld Lead

By A. G. Wikoff†

THROUGH trade custom, the fusion welding of lead is customarily referred to as "lead burning." Strictly speaking, this term is quite incorrect, as the lead is not burned at all and the operation produces a true fusion weld entirely analogous to welds made in other metals, such as steel.

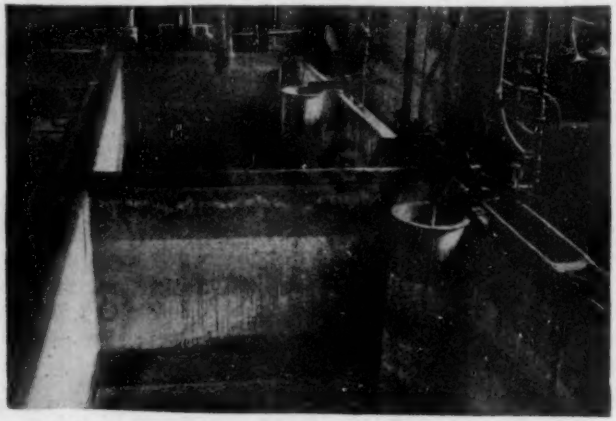


Fig. 1. Lead Lined Tanks

Being a true welding operation, lead welding can be done most satisfactorily with oxy-acetylene welding equipment. Because of the low melting point of lead, only a very small flame is required and it is consequently possible to use a special blowpipe. Welders will experience little difficulty in learning how to work with lead. To be sure, the technique is somewhat different from that required for steel, but the difference is hardly any greater than between steel and aluminum, for example. In many plants, particularly paper mills where lead is used extensively, the welding shop is expected to handle all lead work just as it would any other metal.

*Properties of Lead*

Pure lead is a heavy, soft metal, dull gray in surface appearance, but exhibiting a bright metallic luster on a freshly cut or scraped surface. It has very little mechanical strength and consequently care must be taken to support all large pieces or they will collapse under their own weight.

Where greater strength is required, lead containing antimony is used.

†Technical Publicity Dept., Linde Air Products Company.

The greater hardness of this antimonial or chemical lead is at once evident when an attempt is made to scrape the surface. The freshly scraped surface of antimonial lead has a silvery appearance compared with the bluish tinge of pure lead.

The dull gray surface appearance of lead is due to a coating of oxides

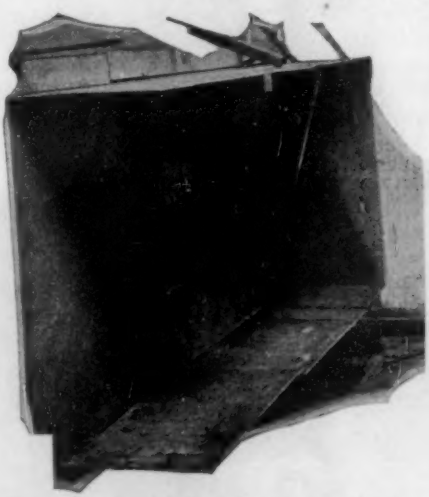


FIG. 2. SUPPORTING LEAD SHEETS DURING WELDING

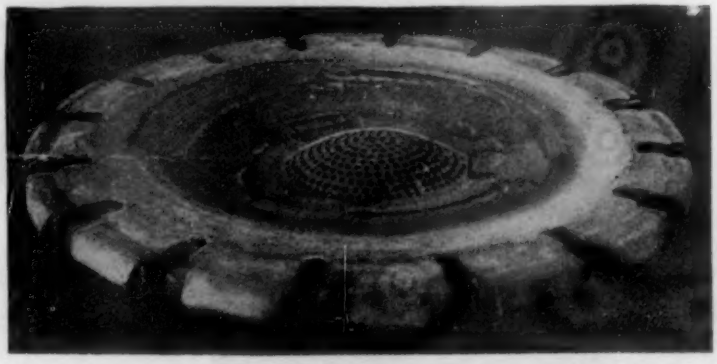


FIG. 3. SULPHITE DIGESTER COVER LINED WITH LEAD

and other compounds that must be carefully removed before welding. For preparing the edges and surface of lead, special tools known as "scrapers" are available. The metal is so soft that the preparation of pieces for welding is a relatively simple matter. The main point is to clean the surface so that thorough fusion will result.

As far as actual welding is concerned, the most important property of lead is its low melting point. This means of course that only a very

FIG. 4. POSITION FOR WELDING LEAD

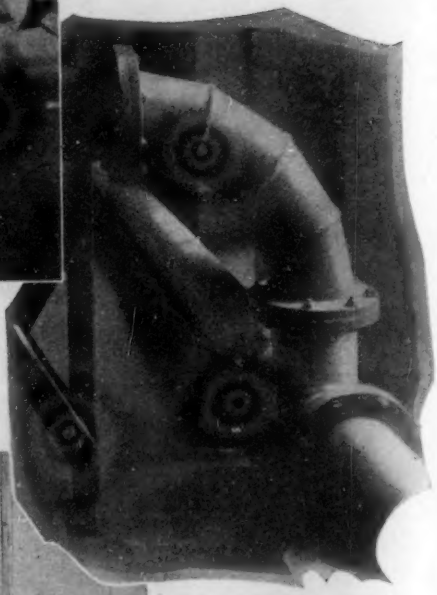


FIG. 5 (RIGHT). FLANGED LEAD FITTINGS WELDED

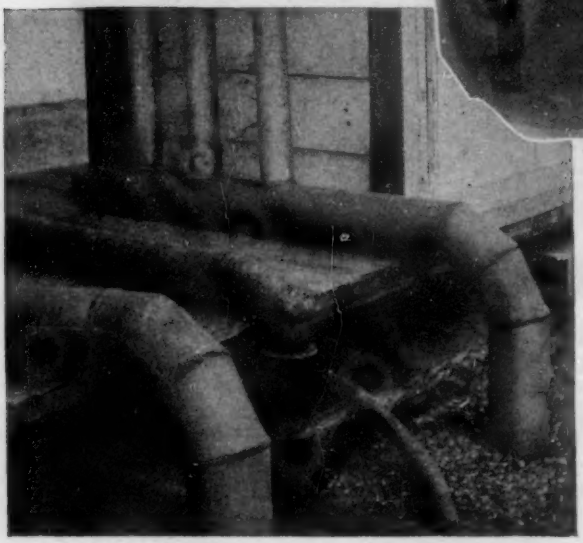


FIG. 6. WELDED LEAD PIPING FOR CONDENSER BOXES

small flame is required. In fact lead melts so easily even with a small flame that the technique of blowpipe manipulation is quite different from that used with any other metal. Best results are obtained with a flame containing a slight excess of acetylene.

Holding the blowpipe so that the flame is almost perpendicular to the surface of the work, and with the inner cone almost touching the surface of the metal, heat the lead until it just melts, then lift the blowpipe quickly in order to prevent excess melting. This will require considerable practice until the operator learns to recognize the exact point of fusion. Lead welding is a delicate operation. The blowpipe flame is directed on the metal for an instant and quickly flipped away. In this

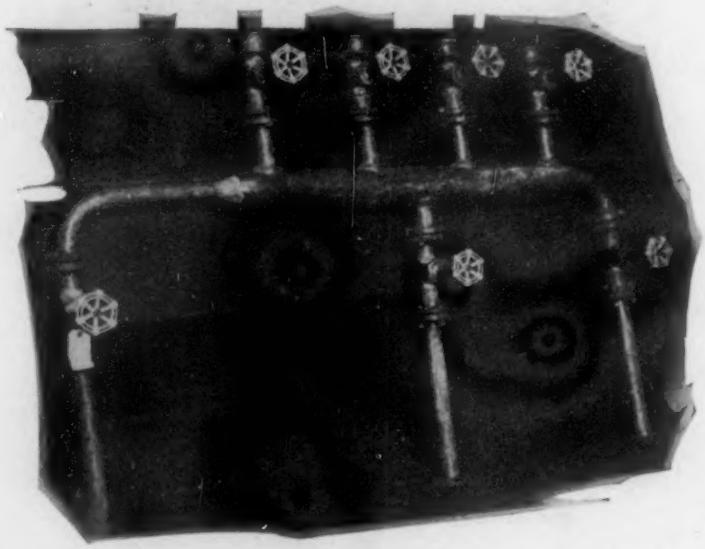


FIG. 7. LEAD HEADER FOR HANDLING CORROSIVE LIQUIDS

way it is possible to control this easily fused metal. Light lead sheet with flanged edges may be welded without the addition of rod, but for most work additional metal is required.

The welding rod, or "burning stick" as it is usually called, may be made by cutting sheet lead into strips, or by melting some lead and molding it into rods of convenient size. Where much work is done, special molds can be obtained. Probably the simplest method is to use a short length of angle iron, melting the lead into the vee of the angle by means of the blowpipe, thus forming a bar of any desired size.

In adding metal from the rod, the blowpipe flame should be played simultaneously on the rod and along the edges of the work to be welded so that they will reach the fusion point at the same time. Thorough fusion is just as essential in lead welding as it is in welding steel. While high strength is obviously not a factor in lead welding, the welds must

be perfectly tight, and this is of course not possible without thorough fusion.

*Welding Sheet Lead*

In most work with sheet lead, such as tank linings, lap joints are used. The sheets are laid out with edges overlapping from ¼ to ½ in. The overlapping surfaces of both sheets must be thoroughly cleaned in addition to the exposed edges of the sheets. Usually forms must be used to support the sheet as the metal is too soft to remain in position unsupported. After the lap joint is in position, the joint should be tapped lightly with a wooden mallet in order to bring the sheets in close contact. Each edge of the lap is then welded, using rod.

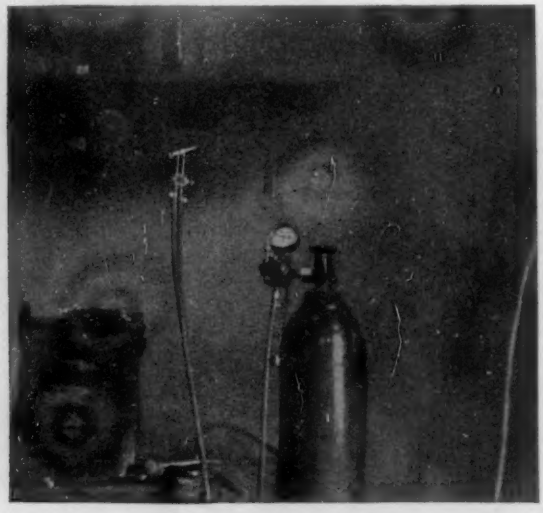


FIG. 8. OUTFIT FOR STORAGE BATTERY WORK

Where it is not possible to work from both sides, as for example when a lining must be made in place, the butt weld is preferable. The sheets are carefully trimmed to size and the edges beveled just as in working with steel. The sheets are supported in position and then tack-welded to maintain alignment. Any shaping that may be necessary in lining up the sheets can be easily done with a wooden mallet.

Vertical seams should be started at the bottom, the work progressing upward.

*Lead Pipe and Fittings*

Lead pipe is obtainable in a variety of sizes and weights, and welded joints may be made by following the same general methods of design that are used in welding steel pipe.

Specials of lead pipe may be made very easily from sheet lead by cutting to size, shaping around a wooden or metal form, and then welding the longitudinal seam.

Flanged joints are used quite extensively in lead pipe work in industrial plants, particularly in the chemical and paper industries. Many of the plants make their own flanges. The flange is molded so as to slip over the outside of the pipe, and has a bevel on the inside edge of the ring so that it can easily be welded to the end of the pipe.

Fittings of all types can be made much more quickly than corresponding fittings in steel pipe. Due to the low melting point of the lead, holes for branch connections are made by simply melting through the pipe wall with the lead welding blowpipe flame. Thus the welding blowpipe also assumes the functions of the cutting blowpipe. The melted edges are of course scraped clean and properly shaped before welding.

FIG. 9. WELDING A TERMINAL CONNECTION

Owing to the softness of the metal, the parts may be made to fit exactly with very little effort. Fig. 4 is a splendid example of the results that may be obtained with careful workmanship. This flanged tee was made entirely with the oxy-acetylene welding blowpipe. Flanges were welded on, the hole was melted for the branch, and then the branch was welded in. In metal of this thickness, welding may be done in two stages. The vee is first welded almost level with the surface; and the joint is then finished, using a rather different blowpipe movement which produces the characteristic over-lapping ripples.

*Storage Battery Work*

It is extremely difficult to weld lead which has been subjected to the action of a strong acid, such as the sulphuric acid used in storage batteries. Where it is possible to neutralize the acid by a solution of ammonia or sodium bicarbonate without getting any into the battery and injuring it, that method is allowable. It is decidedly better in all cases, however, to wipe dry the parts to be burned and then scrape them bright.

The scraping will remove the layer of lead which has been affected by the acid and will insure a good joint.

*Burning Plates to Plate Connectors.*—Set up the plates in a burning rack or comb, which will provide for proper spacing and true alignment. The lugs of the plates must extend above the top of the comb. Place the post in position before attempting to burn the lugs together on a lead strap. To burn, play the flame along the ends of the lugs, and when they are molten, add metal from the burning stick and form a strap connecting them all and the post. A comparatively large flame should be used to insure perfect joints because the plates must be fused perfectly to the strap and post.

If a slotted plate strap or connector is used, set up the plates as described above with the lugs extending up into the slots. To burn, play the flame along the sides of the slots to bring them and the lugs to a melting point at the same time, then add metal from the burning stick to fill up the slots, and finish the strap off smooth.

*Burning Cell Connectors or Terminals to Terminal Posts*—The connectors should be tapped lightly with a small wooden mallet until they fit snugly around the terminal posts. To secure a good burn, it is necessary that the surface of the top of the terminal post be about ¼ in. below the top surface of the cell connector or battery terminal. If necessary, the post should be cut off to insure this feature. To burn, play the flame on the top of the post and bring it and the inner wall of the connector to a molten state, forming a molten pool. To this add metal from the lead burning stick. As the pool fills up, be sure to watch that the metal on the inside wall of the connector flows into and with the added metal. Continue until the added metal is flush with the top surface of the connector. Then allow the connector or terminal to cool sufficiently so that the lead will not crumble when brushed, clean the top with a wire brush, and again apply the flame and add enough lead to smooth off and finish the job.

It is sometimes impossible to burn on a connector or terminal in one complete operation, because the metal surrounding the cavity becomes overheated. In such cases, stop work as often as the lead seems to be running too rapidly, and allow it to cool before proceeding.

In burning on a terminal in which the end of a cable is imbedded, protect the rubber insulation on the cable with a strip of wet cloth, to avoid burning it.

In battery repair shops it is often necessary to build up a terminal post which was drilled out when the battery was torn down. When building up a post, a mold should be used to hold the metal in place. This mold can be made of sheet metal and should be tapered so as to be easily withdrawn from the finished work. Be sure that the top of the post is in a molten state before adding lead, so that the post and the metal added will be solidly fused. Unless this is done, the joint is very likely to be weak.

# Structural Welding*

J. MATTE†

*Welding Gains a Foothold in Structural Field*

FOR years the building profession looked askance at welding. It was considered erratic, unreliable and consequently unsafe. The development of steel shops kept pace with the increasing demands made upon them, so that they could fill the requirements in an economic fashion.

The pioneer makers of welding equipment were hard at work however, perfecting their machine, eliminating defects, simplifying the apparatus and reducing its cost. In their tests they found they could weld steel together quite reliably and, they thought, quite economically. They began to call the iron man's attention to their machine. Some iron men who had vision took on some welding equipment. They had observed that while, as a whole, their regular processes were adequate and economical, occasional fussy work—miscellaneous iron, for instance—requiring little strength, cost them too much to fabricate. They tried Arc Welders on stairs, on door frames, on stack lining rings and other minor structural details. It worked very well. It cost them less than the old type connections. Welding had entered the structural field.

In England some hardy pioneers ventured to prove their faith by welding the trusses of a small building. Later under the exigencies of war some ships were welded and weathered satisfactorily the storms of the sea.

In America, mechanical engineers led the way. They tried welding on pressure piping, on tank work, and even dared to weld locomotive frames. Welding answered their purposes perfectly. Still the building profession looked on askance. Finally business men put the structural engineer in a corner: "We want to build an addition to our store," they told him; "we don't want you to disturb our present enclosing walls until the addition is finished and we don't want you to come into our present premises. What are you going to do about it?" The welder was called in and asked if he could weld on heavy brackets on the outside of the steel columns of the existing building to carry the beams of the new building. He assured the engineer that he could and proceeded to weld on some sample brackets. These were tested with sledge hammers. The brackets were thoroughly battered and twisted, but the welds were quite unaffected. Reasoning that the intended load could never batter the brackets, the engineer took his chances, welded the two buildings together—and nothing happened.

Engineers who have had that kind of experience have absolute faith in welded structures and do not hesitate to use welding wherever conditions warrant it. Engineers, however, who have not had such an ex-

*Presented at meeting of Cleveland Section, A. W. S., May 31, 1928.

†Albert Kahn, Inc., Detroit.

perience remain doubting Thomases. And I want to say that it is quite proper that they should. Engineers have no business taking chances, with their clients' money at stake. Their relation to a building requires that they *shall* be conservative. On the other hand, there is every reason why the welder who knows the uniformity and strength of his work, who sees the advantages that welding possesses for certain purposes in building work, should come to the structural engineer and enlighten him so that the benefits of welding might be made available to others.

*Objections to Welding*

In doing this the welder will frequently find that his statements are questioned; he will meet with some arguments against welding which appear none too easy to answer. I have heard some myself which certainly gave me food for thought.

A common objection voiced against welding is that it depends entirely on the human elements while the established processes do not. Another objection often made is that rivets can be inspected, while welding cannot.

Others say: Welding does not form a positive connection like a rivet: even if a rivet is loose it still has a shaft of metal through the two pieces to be attached, and they remain together. If a weld is bad, there is no union between the two pieces, and they will separate. Those questions and objections cannot be dismissed lightly. Welders must remember that enlightenment proceeds from themselves. Merely telling the engineer that he is an ignoramus and that welding holds anyhow is not throwing any light on the subject.

Consider the question: "What is the strength of a weld?" What is the strength of concrete? After a concrete floor has been poured, is there a man alive who can look at that floor and write on each square foot the strength of the concrete in that particular square foot? Still we are not afraid in the least of concrete construction. The reason is that we supervise very carefully the mixing and that we check the strength of the concrete as we proceed. Of course nobody can tell the strength of every square foot of area, but frequent cylinder tests do reveal the general quality of the material and the factor of safety protects us from scattered weak spots. Experience has taught that such a procedure is perfectly safe and reasonable. So with welding: Nobody can tell by looking at a weld what its strength per lineal inch actually is. But frequent tests are made right along to establish under varying conditions the safe working values which may be used; instead of a safety factor of 3 as in concrete we use a factor of 5 on the lowest test results because of the more recent introduction of welding, and on top of all that, when in doubt we have no hesitation to adding generously to the length of welds required by our calculations.

A very large amount of structural welding has already been done. Loads of over 600,000 lb. have been successfully handled. All this has been accomplished during what might be considered the development period in structural welding, when there was less experience on the subject than we have now. Yet during that period no failure of any kind

has taken place. That is a better record than either ordinary steel construction or concrete can show for the same period.

*Overcoming the Human Element*

The human element has much to do with welding. A welding company has no business to put on anyone as a welder who has not proved his ability by exacting tests.

The head or the manager of a welding company must be a good welder himself and must personally check the ability of all his men. Therein lies the best safeguard for welded work. That is the best way to minimize the human element in welding and it is a matter which can be made mandatory by any building or safety department.

What is true of the head or manager of the welding company is also true of the structural engineer. The best way for him to gain confidence in welding is to learn to weld. If he knows how to make a good job himself, he can soon tell what kind of a job any welder is doing. The time to examine a weld is while it is being laid down and immediately after. The engineer will observe the kind of current used at the electrode, its voltage and amperage, the type of electrode, where the operator starts his fillet, how he develops it, the direction in which he lays it, the rate of progress, the closeness of the electrode to the work, the steadiness of the hand and the sound of the performance. Afterward he will note the absence of spattering, the regularity of the fillet, its adherence to prescribed size and the general appearance of the work.

You see, then, gentlemen, that while allowance has to be made for the human element in welding just as in every other business, excellent safeguards can readily be established and many checks exist directly on the execution of the work.

*Skilled Welders a Necessity*

Let us now look into the statement that even a loose rivet forms a positive connection between two members, while a bad weld will allow the members to separate. That argument implies that the welding is in the hands of an inexperienced operator. There is no question that if riveting is done by good riveters and results in an occasional loose rivet, no harm is done; and it is most certainly true that if welding is done by journeymen laborers, it will not stand the comparison of even poor riveting. But just as that comparison is ridiculous, so is the argument ridiculous. What engineer or builder ever has or ever will let a welding contract to a firm that employs as welders men who haven't the slightest knowledge of the work? Of course the engineer or builder does not know the man or men sent out by the firm to execute the welding, but the engineer or builder most certainly does inquire into the standing of the welding firm he deals with, and no welding firm with a good standing sends out amateurs to uphold its reputation. That argument can just as well be turned around the other way. Even a pretty poor weld will form a good connection compared to one consisting of burned rivets heated and driven by inexperienced laborers.

Good welding can be secured just as easily as good riveting or as good concrete. The results obtained so far in structural welding prove that

beyond any argument. But just as it requires constant care and attention to get good rivets and good concrete, so does it require the same amount of care and attention to obtain good welding.

Probably as time goes on many improvements will be made to welding equipment, but even in its present state there are certain structural operations which lend themselves very naturally to welding.

*Adding to Existing Structures*

Whenever a building is to be enlarged you will find that it pays to consider welding the two structures together. It naturally suits the owner better to carry on his business without any interference while the addition is going on than to be interfered with. You can't back rivets without going through the existing wall while you can weld to the outside face of the existing steelwork.

Large houses, country clubs and similar structures are usually provided with complicated hip and valley roofs, the steel frame of which is very intricate. To spend days and weeks drawing up elaborate details of such framing and of its connections is pure waste of time. Send plain steel beams, channels and angles to the job cut square at the ends and of generous lengths; send also a burner and an arc-welder. You will find that the job can be put up much more quickly and satisfactorily by handling it in the same way as a carpenter builds a wooden frame. The bevel cuts and skew connections required are obvious when the rafter or purlin is in its approximate position, and a burner soon fashions it to its exact shape, with proper clearances to swing in place. If shaped in the shop, the various cuts are made with a burner anyway, so they might as well be made right in place. Of course a burned edge must not be welded directly, but if you provide an assortment of small rectangular sheared plates, your welder will employ them at points where the burner has been used instead of making a direct weld.

Bar joist construction is being used more and more, and for larger buildings than heretofore. The Grant Building in Pittsburgh has bar-joist floors: it is 35 stories high. Wherever bar-joists are carried by a steel frame they are attached to the frame. Various kinds of friction clamps have been used for this at one time or another, but the right attachment for bar-joists to steelwork is by means of tack welds. The cross-bracing or so-called bridging of bar-joists has frequently been made by cross wires twisted together. This is a very poor detail. A more effective system of bracing consists of one or more lines of ¾ in. tie rods welded to the underside of the top flange of each bar joist, the ends of the tie rods being welded to a horizontal channel or other suitable lateral stiffener attached to the end beams.

*Welding Details*

The right way to build a steel swimming tank is to weld it. When you rivet and caulk such a structure you know that if the building should settle a little for any reason, some rivet would spring a leak. For that reason it is necessary to line the tank with a waterproof felt. If the tank is welded and suitably painted the felt lining is eliminated. As a

matter of fact I know of two riveted tanks which gave me so much trouble when they were tested that welding was substituted for caulking. It would have been cheaper to weld them entirely in the first place.

In factory construction innumerable holes are needed in the steelwork for pipe coil hangers, motor stands, sash operators, and for securing the sash itself. Welding is of great assistance in this kind of work as most of the holes have to be made in the field. It is also economical, because the welding consists almost wholly of short tacks and a single man can cover much ground.

In power house construction welding is increasingly used in the fabrication of coal and ash hoppers, and I know of at least one case where large coal bunkers have been built without a bolt or a rivet.

*Alteration Work*

In alteration work of any kind which involves changes and additions to existing steelwork *there should be a welder on the job.* That kind of work is fraught at every turn with vexatious delays due to unforeseen conditions. The field measurements are usually taken by experienced and careful men, but most of the time they cannot see the steel they are locating because it is buried in masonry; they cannot find before the masonry is removed that field changes were made when the building was constructed, nor can they make allowance for inaccuracies of erection which may have existed. They have to go by measurements that they can get and by an old set of plans. It is from such information that the drawings are made and the work fabricated. It stands to reason that if plain material is sent to the job together with a stock of small rectangular sheared plates, and that the work is executed with burners and welders, unforeseen conditions are met right on the job without having to wait for correction drawings and additional shop fabrication.

A few weeks ago I noticed the time it took to place a new 12 in. beam weighing less than 500 lbs. between two old columns. It took 7 men 1 hour 35 minutes to do that. In the next panel where another new beam was to be placed between two old columns, the shop-riveted end connections were first knocked off and the beam shortened a little by burning one end off. At the burned end the connection angle was welded on again. The beam was placed by the same gang in 20 minutes with one end bolted and the other roped in place ready for the welder. Elsewhere it took 7 men 50 minutes to place a 15 in. beam weighing 675 lbs. The trouble was due to a shop-riveted connection at one end which did not have quite enough clearance, and consequently was very hard to fit. If that connection had been left off, the beam would have simply slid in place and could have been welded later.

There are innumerable circumstances in which welding will reward the engineer who thinks of using it. Suppose that a foundation under a column has to be replaced by another having a greater capacity. The engineer can weld some brackets to the column, place suitable girders under those brackets and carry the ends of the girders on temporary foundations. That permits removing the original footing and building a new one in its place. Now the column itself has to be reinforced. Addi-

tional bars are readily tack-welded on to the old column, and to the existing connecting beams so that the column can carry a much greater load than before.

If a new mezzanine floor is needed in an existing building, beams are welded to the existing columns, precast concrete slabs laid on the beams, railways welded on and in an incredibly short time the new mezzanine is ready for business. Compare that to the old way: making elaborate shop details, fabricating the material in the shop, trying to fit in on the job, riveting it up, and pouring a messy slab over the beams and over everything else, and you see that even in the old building profession better methods are being used than formerly, and in these better methods welding plays a prominent part.

*Changes in Plans*

It frequently happens that after the frame of a building is under way, changes affecting the steel are required for one reason or another. Such changes formerly just tied up completely that part of the job adjacent to the desired change. It was necessary to wait for new shop details to be made and approved, for new holes to be drilled, and for new steel to be placed. Welding has simplified matters wonderfully. Today we send on some plain material and just weld it in place without stopping the job for a minute.

Suppose that a new building is to be erected with several basements adjoining a building with a single basement. Suppose also that the columns of the two buildings are adjacent to each other. It is, of course, necessary to underpin the old columns, a bright scheme for doing this consists in welding some diagonals between the foot of the old columns and the shaft of the adjacent new columns, thus throwing the load of the old columns onto the new ones while these new ones are still only partly loaded, since the new building is in process of construction. This permits removing the foundation under the old columns and putting in the underpinning. That done, the diagonals are burned asunder and the old column's load is automatically transferred to the underpinning.

Do not think, gentlemen, that my supposed cases are really hypothetical. I can name the job where each one of these cases was actually performed. Many of those supposed cases have been executed several times. I know of an alteration job on a huge scale going on at this moment. New elevator, dumb-waiter and paper chute shafts are being built into an old building; new columns are being substituted for old ones; mezzanine floors are being put in and old columns strengthened. The entire operation is being handled by welding, in two shifts, ten welders to a shift. Beams, angles and plates are sent to the job absolutely plain; they are cut to length and to shape by burners and tacked in place. They are then welded up, the length of the welds being proportioned to the loads to be carried.

*Field of Application Growing*

A welder on a structural job reminds me of an oil spot. Let a drop of oil fall on a sheet of paper. It's only a drop tonight; look at it tomorrow morning; the drop has spread all over the paper. You start a

welder on a job to perform a certain definite work. The first thing you know he is all over the place, hard pressed to meet the requests for assistance that come from every direction. On a job recently while the welder was doing the work that had been assigned to him, he was requested by the steel erector to help him at different places to tack or weld beams because the erector needed his compressor elsewhere and consequently could not rivet them; then the plumber got him to weld piping to the tanks; finally the escalator man who was having his troubles trying to fit his work to beams which were somewhere else than expected pressed the welder into service, and the escalator was welded to the building.

*Welding in Reinforced Concrete Construction*

Even in reinforced concrete construction there are occasional demands made on the welder. When a concrete column starts from the top of a steel column or girder, the simplest way to secure the reinforcing bars to the steel below is to weld them together.

When very large concrete columns are used, instead of reinforcing them with an abnormal number of small rods which cannot be effectively staid, it is advantageous to use rails. The logical way to secure an upper tier of rails to the tier below is to weld them together. The rails have to be staid; the simplest way is to weld flat bars horizontally or diagonally to the rails.

When it is necessary to reinforce concrete beams against torsion, or when for other reasons the shear requiremnts demand an abnormal number of bent rods, it is sometimes advantageous to weld short diagonals between top and bottom reinforcing bars. It leaves more room to pour the concrete than if all those extra diagonals had to be developed by top and bottom laps.

*Field for the Oxy-Acetylene Cutter*

On all jobs we find a burner. We simply cannot get along without it. I venture to say that very soon we will rarely see a job on which there is not also an arc welder.

Just as welding has already created its own sphere of activity in the field, so has it found a place for itself not only in the miscellaneous iron, but even in the heavy structural shop.

I have seen rolled steel slabs 10 in. thick which had been drilled for anchor bolts. Those slabs were used as column bases. It takes a long time to drill steel 10 in. thick. It is simpler to weld two angles to the top of such thick slabs, letting the angles project beyond the slabs. The anchor bolts can perfectly well be placed beyond the slabs through holes in the angles, and the column can be welded to the vertical leg of the angles. There is a case where a little welding permits shipping the slabs directly from the mills to the job, instead of passing through the fabricating shop just to drill a few holes.

*Welding as an Aid in Transmitting Stresses*

When a concentrated load is carried on top of a built-up girder it is necessary to carry the entire load to the girder web by means of stiffener angles. The chord angles of the girder are set a little above the top of

the web because of the unevenness of the edges of the plate. Consequently, the load does not bear directly on the web. The stiffener angles have to be fitted under the flange angles of the girder, so that the load will get a bearing. Of course, the top of the stiffener leg which attaches to the girder is of no great use to carry the load, since it has to be trimmed to clear the fillet of the chord angles. Now, if after assembly, the gap between the back of the chord angles above the top of the web plate is filled in by welding and the weld smoothed with a hand grinder, the load will bear directly on the web through the weld metal. Similarly, if the stiffener angles are welded to the underside of the chord angles, no fussy fitting is required and both legs of the stiffeners are fully utilized to carry the load. It is evident that if a part of the load is delivered directly to the web, no stiffeners are needed to carry that part of the load, and that if both stiffener legs ar effective, instead of only one, the stiffeners can be lighter than they otherwise would be.

In girders and trusses, compression chord splices are not made by butting the opposite section because of the irregularities of the sheared ends of plates and angles: consequently, many rivets are driven to unload one chord section into the connecting gussets, and again to transmit the load from the gussets to the opposite chord section. If the gap between the abutting chord sections is filled in by welding, it gives the same result as if those sections were milled, and consequently much riveting can be eliminated.

There is no question that welding already has a broad field of usefulness in structural work. In locomotive, automobile and tank work, welding is pre-eminently a shop operation. In structural work, welding has more numerous and important applications in the field than in the shop. Structural shops are equipped with shears, multiple punches and bull riveters which handle the work not only with great economy but also with great speed.

*Field Welding*

Less than a year ago the cost of field welding was so high that it could not be used instead of field riveting except under special circumstances. The time required to weld, compared to that required for riveting, was also considered a serious objection against welding. A great deal of work has been done since then and much better quotations are obtained from welders than heretofore. The consequence is that when the two operations are designed on an equal basis and handled right, there is not much to choose between them. As an example, compare the costs of web connecting an 18-in. I to two other beams, one at each end of the 18-in. beam and perpendicular to it. For riveted work the shop cost of two pairs of standard connection angles and eight shop rivets is $2. The cost of sixteen field rivets in place is $4. The total cost riveted is then $6. If the beam is to be welded, it should be welded for the same safe load as the rivets can carry. The sixteen field rivets have a value of about 80,000 lb., with an ultimate value of probably close to 400,000. For equal capacity, one end of the 18-in. beam would be welded directly to the transverse supporting beam with about 16 in. of weld; the other end, because of the clearance gap required for erection, would need a pair of small plates which would be secured to the 18-in. beam by 16 in. of weld

and to the supporting beam by another weld 16 in. long. We would then have two plates worth about 50 cents each and 4 ft. of weld costing $1.25 per foot, or a total of $6, just as for a riveted connection. Now, considering the matter of time: a gang of field riveters will drive about thirty rivets per hour, making allowance for the time needed to move from one point to another, to set up scaffolding, etc. It will then take about thirty minutes to drive the field rivets. Making allowance for moving about, for scaffolding, etc., a welder will lay about 4 ft. of welding per hour. So the 4 ft. of welding mentioned will require one hour, but if two welders are used simultaneously, the job will require thirty minutes, just as riveting does.

Everything points to a vast increase in the use of field riveting in structural work, and there is absolutely no doubt that the outlook is very promising. Some time ago I heard it remarked that welding companies would derive no benefit from structural work after they had demonstrated its value, because structural steel companies would do all the welding themselves. It must be remembered that structural steel companies are primarily manufacturers and as a rule prefer to sublet the erection to companies skilled in that particular work. In the shop one job follows another, and all are handled along the same general lines. The erection has to be executed in different localities, under varying conditions which call for methods suited to those conditions. Instead of being a continuous manufacturing process, erection in any particular location is spasmodic. As the use of welding in steel erection increases, so will the demand for experienced and reliable welders, but the demand will be intermittent. It is logical that the demand be filled by welding companies who have been licensed by the Building and Safety Departments, who have trained the men, who stand responsible for their fitness, and, above all, who have in their shops other kinds of welding work to equalize the intermittent demands from the structural steel business and to furnish steady work to the men employed. In general, reliable men prefer steady to intermittent employment and to drifting around from one place to another on the chance of getting a job. It is natural, then, that the good welders will be found in shops of welding companies, and that is where the steel business expects to find them.

*Cooperation Needed Between Welders and Builders*

There is no reason, either, why welders should do nothing but welding. A steel job can be erected by the Smith Erection Company with the help of welders furnished by the Brown Welding Company, but that steel job can also be handled by the Jones Erecting & Welding Company. That means that the welder has personally entered the structural field. Well, I am convinced that if welding is to expand, it is absolutely necessary for the welder to enter the structural field, to show the architect, the engineer and the steel erector the practical economies that can be effected, to show them how they can be obtained and to work out the necessary details. A few moments ago I said that when field riveting and welding are compared, there's not much to choose between them. That's an engineer's statement. If I were a welder I certainly would not say that. I would say that, when such a comparison is made it decidedly favors welding, and I could prove it. Consider again an 18-in. beam 20 ft. long, and

which is to be framed to a column at each end, resting on a shop riveting seat, with a top clip angle field riveted to give stiffness to the connection. The column shop work would be about the same in either case. The field work would cost about the same, whether riveted or welded, and the time required would be the same. But notice that for field riveting the beam would have to be shop punched at a cost of $1.10, which would be saved if the field work were welded. If there were a thousand beams like this in a good-sized job, that one item would show a sizable saving. But notice further that, for welding, that beam is absolutely plain, and consequently can be shipped cut to length from the mill directly to the job without ever going near the fabricating shop, saving two handlings, or about $1.65 more. So, for a thousand such beams in a job, that one little item would save $2750. Now, suppose the welder sees a dozen such items in a proposed job and that he undertakes to draw the attention of the architect, the engineer and the erector to them, do you suppose he is going to be ignored?

Today the welder is called in at times by the engineer, but only on special occasions when the case is so difficult that the established processes fail him and that, consequently, welding is called to mind. For ordinary purposes if welding is not used, the welder has but himself to blame. How can the architect or engineer think of welding if he doesn't know a thing about it? Do you suppose that the designer has time to go into details when he has to get out the structural work for a million-dollar job in four weeks or less? It behooves the welder to study the usual connections and details used in structural work, to analyze their costs carefully, think seriously and to design corresponding connections and details for welding. The welder does not have to follow blindly in the path of established precedent. A very little study will show him that economical field welding requires connections which allow gravity to carry the load on shop fabricated seats, the welding being limited to tacks securing the steel in the position desired. Obviously, the greater the number of feet of welding required by the proposed details, the higher will the cost be and the longer the time required to perform the work. It has been attempted to save some steel tonnage by introducing in steel beam design the continuous action usually obtained in concrete. This requires so much field welding that the extra cost of welding and the extra time required for executing it overbalances the saving in steel. Consider, again, an 18-in. I beam 20 ft. long framed between top and seat angles on a column at each end. The field work, either riveted or welded, would cost about $1.50 at each end. If continuous action were introduced, a 15-in. I could be used instead of the 18-in. beam, saving about $6.50, but the flange of the 15-in. beam would have to be welded to the column with the help of flange plates; additional plates would have to be provided and welded between the column flanges, and the connections would cost from $10 to $15 to save $6.50.

Detailing is the science of locating holes at the right place. Detailers have to locate not only holes needed for shopwork, but also those required for field connections. If field holes are largely eliminated, it follows that detailing can be done more expeditiously and at less cost. But if the welder lays back instead of working out his own details, the detailer will have to locate holes for the shop and design welding details for the field.

As he does not have the experience that the welder has, he is likely to draw up details which do not suit the welder, and which make his work expensive.

*Cost an Important Factor*

It is plain that costs have everything to do with the expansion of welding. If welding costs more than riveting we will have no welding. If it costs less, and the welder proves it, it will be used. The welder must study his costs carefully and from every angle. Welders engaged on field work share the risks of the steel worker, and workmen's compensation insurance rates are the same for one class of men as for the other. But the rates for public liability insurance are also the same. The welder does not hoist the steel, does not swing it out over the streets, and does not operate the derricks. But in structural work the welder is a newcomer, and so far insurance rates for steel erection are applied to him.

Welders have objected to specifications requiring them to furnish a bond. It must be understood that the architect's or engineer's first duty is to his client, and it is his business to make sure that contracts will be carried through and completed on time after they are entered into.

*Standardization Important*

Drawings show what work is to be done; specifications explain how the work shall be done. To write a good specification it is necessary to have an intimate knowledge of the subject. At present the technology of welding is not well known by the very individuals whose business it is to write the specifications governing its execution, and they naturally look to the welding profession for information. After familiarizing themselves with structural steel operations, welders should draw up a standard specification for building work which, while sufficiently elastic, still embodies and safeguards all the important details of the work.

Surveying the present status of structural welding, we see that, while emphasizing the need of careful work, objections to welding apply equally well to other lines of endeavor which have the full confidence of everyone; we see that protection can readily be secured by wise and reasonable building department regulations, and we observe that, far from it being impossible to check welded work, effective supervision can be provided. We note that many structural conditions are best met by the use of welding, especially in the field and that, thanks to lowered costs, it is possible to extend the use of the art still more, provided that welders put their shoulder to the wheel and work in cooperation with the builders. It is apparent that the extension of welding will be of benefit to welding companies and that, because of interdependence, cordial relations cannot fail to materialize between the building and the welding professions.

I did not come here tonight, gentlemen, to eulogize welding unduly, but it has certainly become an art without which we cannot do. New requirements are temporarily met by makeshifts, until the right tool or the right process is discovered and made known. Nails can be driven with a piece of gas pipe, but most of us prefer to use a hammer; the hammer is the right tool for the purpose. Similarly, for its purposes and in its place, there is no simpler nor more adequate process than welding.

# The Electronic Tornado Principle of Welding*

J. F. LINCOLN†

SEVERAL years ago research engineers of our Company experimented with the Electronic Tornado in the course of their work. At that time it was thought to be merely an interesting scientific phenomenon of no particular commercial value. However, they continued their experimentations with it, and in December of last year produced a series of welds of such extreme ductility and smoothness that their efforts to apply it to commercial machines were redoubled.

After considerable effort a practical welding head using the Electronic Tornado was produced. One of the early machines in which it is embodied is shown and described in this article.

The electric arc is normally a difficult phenomenon to control. It creates its own magnetic field, and in the passage of the welding current through the parts being joined, creates other magnetic fields of variable direction. The arc, therefore, tends to wander about seeking the path of least resistance, between its own magnetic field, produced by the passage of welding current, and the piece being welded. By super-imposing a strong magnetic field on the arc flame a control of the arc is established. This control permits the arc to travel through the variable fields without disturbance. The arc is given a gyratory motion of great velocity which also tends to hold it in a straight line.

In the first announcement of the Electronic Tornado, the opinion was advanced that its application to commercial machines would substantially reduce the cost of present day welding. A very practical demonstration of the verity of this belief has been given in the automatic welder shown here.

In general the cost of welding of say, one half inch plates including operators' time, electric current and carbon electrodes will not exceed seven cents. The cost of welding plates of other thickness will be in direct proportion. Whereas heretofore the metal deposited by electric arc welding has partaken of the characteristics of cast steel, the metal deposited by the Electronic Tornado weld has so much better physical characteristics that it approaches very closely the character of the plates which it is joining.

The test welds that were made by the Electronic Tornado were subjected to the severest tests that could be devised, and in every case showed as great ductility and strength as would equivalent sections of mild steel. The welds, after having been made, were sawed from the plate and the resultant bars were twisted through 1,080 degrees, or three complete revolutions, without showing any indication whatsoever of failure. Other such bars were twisted cold and tied in knots without

*Presented at meeting of New York Section, A. W. S., May 15, 1928.
†Vice-President, Lincoln Electric Co., Cleveland, Ohio.

fracturing. The refining effect of the new welding process produces metal in the weld fully as good as that which can be obtained in rolled steel of the same general purity.

To come directly to the application of the Electronic Tornado to a commercial machine, the illustrations should be consulted. Figure 1 shows the machine at rest. It will be seen that there are two of the new type welding heads with their electrode holders crossing each other at a sharp angle. This construction is of particular interest, for with an uncontrolled arc it would be absolutely impossible to operate two flames in such close proximity. One would continually blow the other out. With the Electronic Tornado head, however, they work smoothly and without confliction.

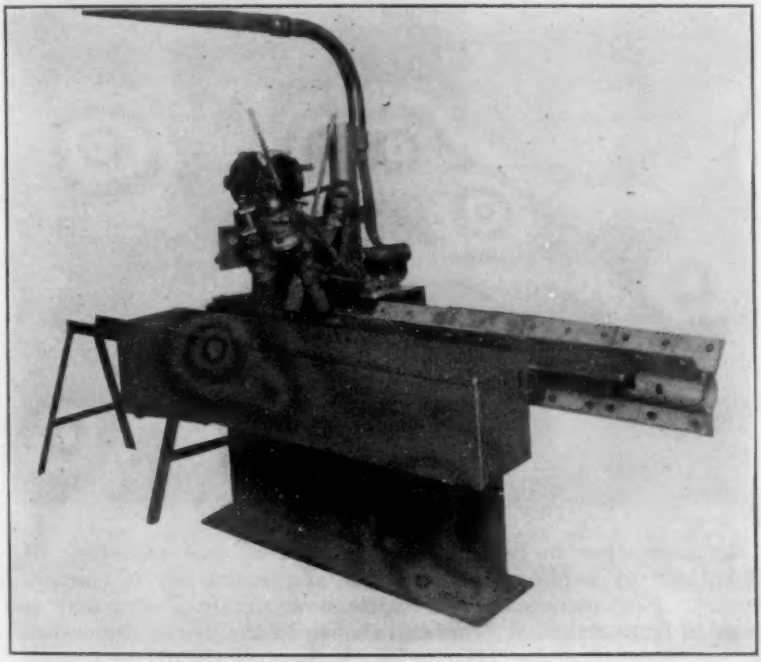


FIG. 1. COMPLETE ELECTRONIC TORNADO WELDING MACHINE FOR WELDING OIL DERRICK CLAMPS

This automatic welder was designed to produce Oil Well Tubular Derrick Corner Clamps such as the one shown in the center of Figure 2. These clamps, as you will see, are made from three pieces of plate whose aggregate radius bending totals a complete circumference. These pieces are placed in the assembling machine, where they are tack welded.

The operatioin of this device is very simple, there are three little air clamps operated by the valve handles. When these are compressed the various pieces are closed about a mandrel and held in position; while thus secured, an operator with a hand torch spot welds them at the end.

The caps thus assembled are fed into the big welder and are carried under the arc in a continuous progression by chain on which there are dogs set at the proper intervals.

The welder in operation is shown in Figure 3, where the operation of the crossing arcs is clearly visible.

This new automatic Electronic Tornado welder is placing welds at the rate of better than 40 ft. an hour for each head, which is an exceptionally high velocity. No filler rod is used, the arc fuses the various plates inseparably together.

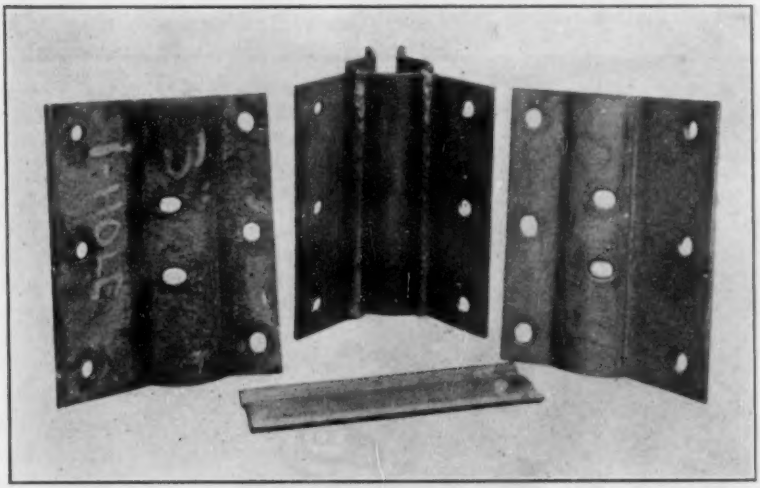


FIG. 2. IN THE CENTER IS SHOWN ONE OF THE FINISHED DERRICK CLAMPS. IT IS MADE OF THE OTHER THREE PIECES SHOWN AND WELDED BY THE ELECTRONIC TORNADO DEVELOPMENT WITHOUT THE USE OF FILLER ROD

It is interesting to note the construction of this machine. It was built entirely by welding and is graphic of the new day in machine construction. Few manufacturers realize how simply a structure can be elaborated from standard structural shapes by the use of the electric arc. That knowledge, however, is coming to them more and more, and this demonstration of it seems to us particularly apt.

What the great future of Electronic Tornado welding may be, it is impossible to know at the present time. It is commercially feasible and practicable and it produces welds that are very ductile and much more economical than any other welding process heretofore developed.

This Electronic Tornado is already being applied successfully to the manufacture of pipes, tanks, range boilers, steel barrels, rear axle housings, and many such products. The extreme ductility, the elimination of porosity, and the smooth appearance of the surface make it the natural method for accomplishing these results. It will do such work cheaper than any other known method, and at the same time make a

weld which cannot be approached by any other method of autogenous welding.

This immediately opens up a very interesting new field which has been closed heretofore because of the lack of ductility of weld metal and

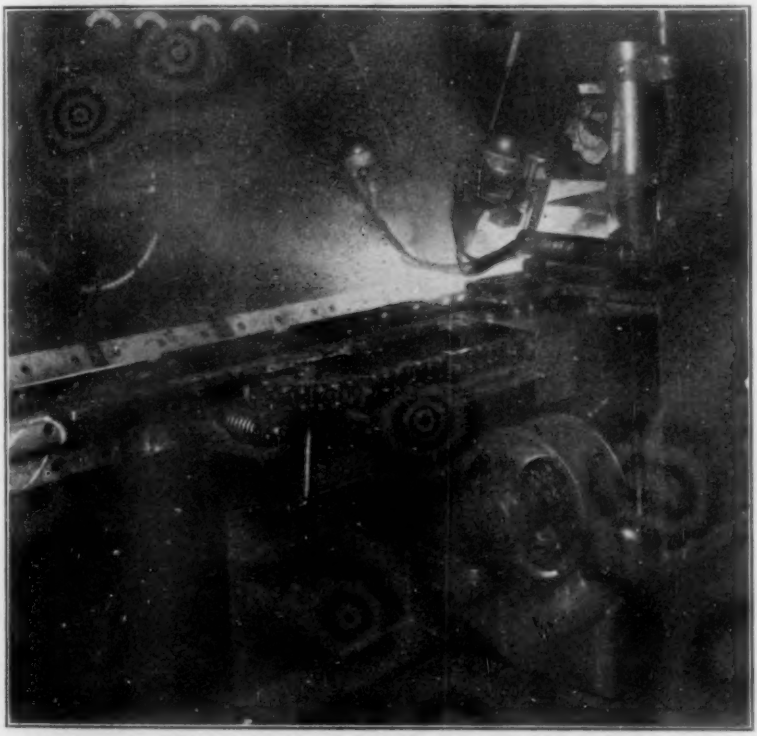


FIG. 3. THE ELECTRONIC TORNADO DEVELOPMENT OF WELDING IN ACTION. IT IS AN AUTOMATIC WELDER PRODUCING OIL WELL DERRICK CLAMPS. THE GUARDS OVER THE CHAIN HAVE BEEN REMOVED TO SHOW THE METHOD OF CARRYING THE DERRICK CLAMPS UNDER THE ARC

also the doubt as to the ability to weld continuously without variation of the quality. This makes possible the welding of steam boilers, air receivers, and other pressure vessels which so far the code does not allow to be welded.

When it is remembered that these welds made by the Electronic Tornado have characteristics which from every point of view are equal to the plate from which the welds are made, and in many characteristics show even greater strengths and ductility than the plate itself, it is self-evident that the objection to this work being done by automatic welding must be removed.

The result of this is going to be very far reaching and undoubtedly will have tremendous bearing on the future of manufacture and design of products of this kind.

# Welded Automotive Shop*

A. B. VILLADSEN†

WE obtained a contract to weld the Associated Oil Co.'s Automotive Shop in Emeryville.

The roof area of this structure is 66,600 sq. ft. supported on 52 trusses, 60 ft. span spaced 20 ft.-0 in. Height to the bottom chord is 17 ft.-0 in. The liveload was figured 20 lb per sq. ft.

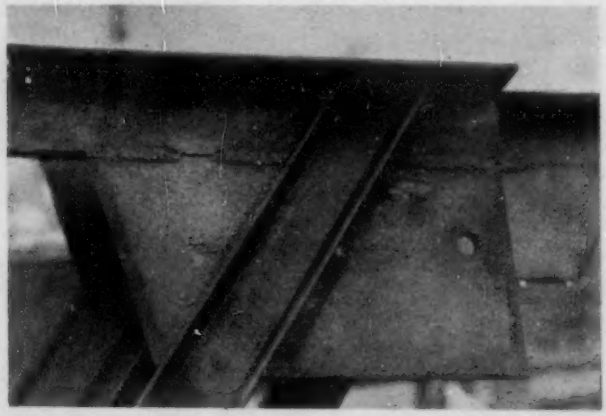


FIG. 1. END OF TRUSS WITH PLATE WELDED TO TOP OF CHORD LARGE ENOUGH TO FORM AMPLE WELDED CONNECTION WITH COLUMN

The building was first designed as a standard riveted structure, but at the suggestion of Mr. J. C. Bennett, we asked to substitute a welded steel structure in its stead.

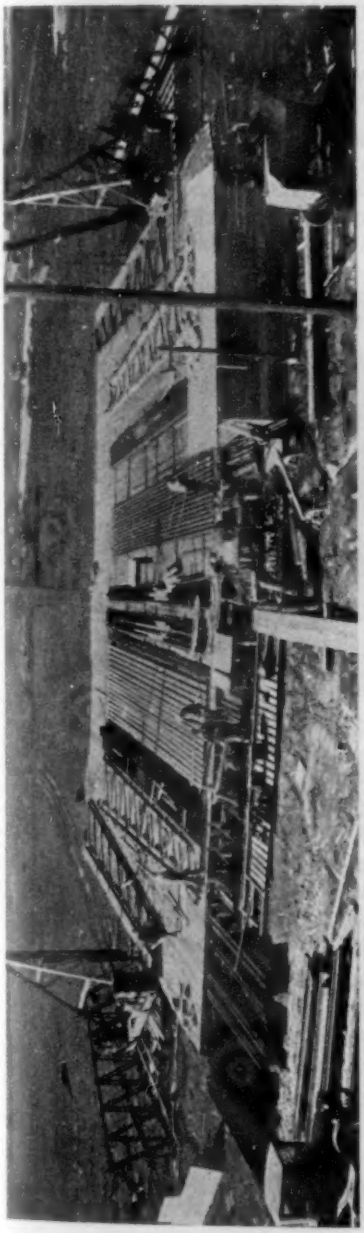
We were glad to do it, first because we liked to try something new and also because we could save 11 tons of steel or 10 per cent of the weight of the riveted job.

Several different designs were made to see if other shapes than angle iron could be employed to advantage, but it was found that a truss made up of pipe as compression members and flat iron as tension would cost as much as the angle iron truss mostly on account of the high price of the pipe.

The trusses were made out of angle iron and channels, and are very light in appearance. The sections were much smaller than in the riveted truss as no additional steel is carried for rivet allowance and no gussets were needed to tie the members to the chords. As a matter of fact only 2½ in. leg was required to give sufficient welding surface.

*Presented before San Francisco Section, A.W.S.
†Villadsen Bros., Inc.

Due to the continuous action of the 3 span design, heavy compression was developed in bottom chord at center column and it was necessary to reinforce this section; by adding ¼ in. x 5 in. steel plate to the horizontal legs of angle with a 1 in. weld every four inches.



WELDING PLATFORM AND STOCK PILES

FIG. 2. TWO TEMPLETS HELD THE STEEL IN PLACE WHILE THE STRUTS ON THE UPPER SIDE WERE WELDED TO THE CHORDS. THE TRUSS AT THE FOOT OF THE DERRICKS HAS BEEN TAKEN OUT OF THE TEMPLETS AND TURNED OVER AND IS READY TO HAVE STRUTS ON THE OTHER SIDE WELDED TO THE CHORDS. A STRUCTURAL ENGINEER ACTING AS FOREMAN AND FOUR WELDERS AND TWO LABORERS FABRICATED FOUR TRUSSES PER DAY

FIG. 1. GENERAL VIEW OF STEEL ERECTED

It was also found that shear at this connection between top chord and center columns was so high that additional plate was required to give welding surface enough at the column.

On the lot next to the building site a platform was built with a 1 ton derrick at two sides.

The steel was brought to job cut to lengths. On the platform was placed two templets in the shape of trusses in which the members could easily be clamped in place.

The procedure of the work was then so arranged that while the welders worked one truss, another was being prepared for them, then while they welded the second truss, the first was lifted on the templets turned over and laid on platform outside templet and the remaining members clamped on with iron clamps; thus there was no stop to the operations.

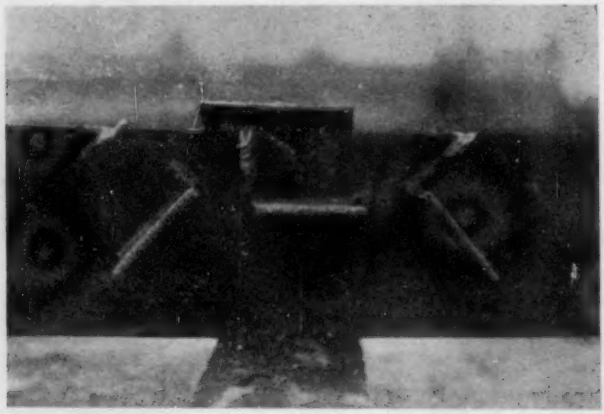


FIG. 4. ANGLE CLIPS WELDED ON BOTTOM CHORD FOR BRACING

The welding work was done by the Brown Bros. whose hand picked, highly skilled men performed a perfect job and there was not one single bad weld which had to be done over or showed weakness in any way.

After having welded about half of the trusses we decided to pick one at random and test it to see how it would behave under load. It was overloaded 45 per cent and acted as it should with a deflection of ¾ in. which sprung back when truss was again unloaded.

Before starting erection we set all the base plates for the columns to exact level, and after the trusses and columns were erected lined up and plumbed, the bottom of the columns were welded to the base plates. This gave a perfect bearing for the ends of columns which were not milled.

There was only one bolt hole in the trusses; this was used for erecting purposes, and we were able to erect a large area of the building without interference from the welders, who followed up at their leisure.

To illustrate how easily the work went, it should be mentioned that 15 trusses were erected in eight hours with one derrick.

# Tenants Undisturbed by Half Million Dollar Alterations to Old Building

A. F. DAVIS†

TENANTS of the 10 story Rose Building, Cleveland, Ohio, are carrying on business in their regular manner undisturbed by alterations to the building which will cost approximately a half million dollars when completed. It is said to be the largest building operation of its kind ever attempted in Cleveland.

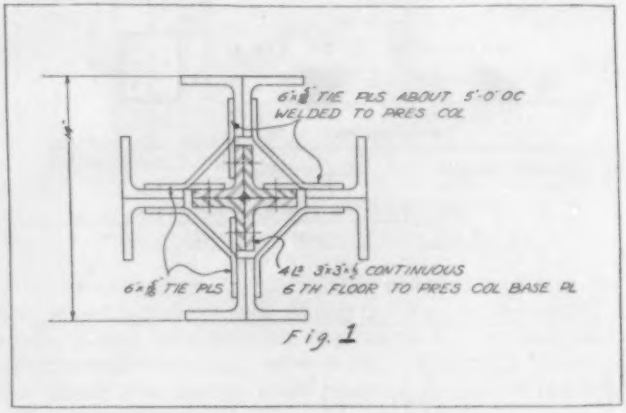



Fig. 1

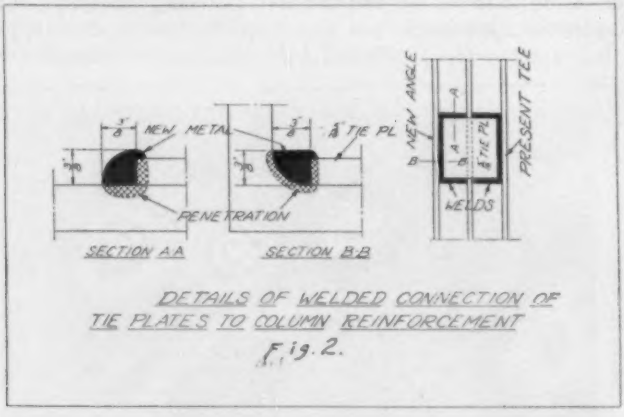
This office building, which houses mostly physicians and dentists, was erected in 1898-99. Due to its obsolete design many difficulties were encountered by William Robert Powell, architect, and Carson G. French, structural engineer, of Cleveland, in the preparation of plans for the present alterations. One of the greatest difficulties presented was the loss of most of the drawings showing structural details of the old building. The obstacle was overcome by the decision to cut the steel in the field whenever necessary, with a gas torch, and to make all connections to the old framework by the electric arc welding process.

By use of this modern method of joining steel it was necessary to make only small openings in the old walls uncovering only the face of the old steel where the connections were to be made. In this way much wrecking was eliminated and due to the fact that the arc welding process is silent, tenants of offices adjoining the building operations were unmolested. In fact, teeth are being filled and ailments treated in rooms adjacent to where the welder operator is welding. It is estimated that

†Vice-president, Lincoln Electric Co.

the owners of the Rose building are saving thousands of dollars in rentals by the use of arc welding for making field connections.

Included in the alteration project is the addition of four stories on top of a portion of the building which was originally six stories high. The old columns in this section of the building were not originally designed to carry additional load. They are of the Gray type, made up of four tee shapes held together by straps riveted to the legs of the tees, thus the columns were given a circumference octagonal in shape, the center of the columns being open. To stiffen these columns and give them




DETAILS OF WELDED CONNECTION OF TIE PLATES TO COLUMN REINFORCEMENT

Fig. 2.

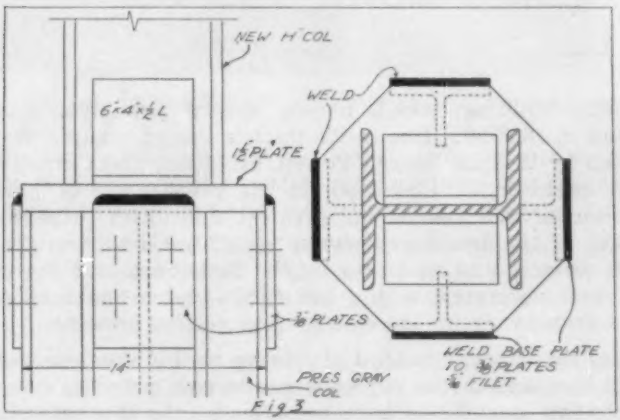



Fig 3

greater load bearing capacity, sections in the shape of a cross made up of angles were inserted in the hollow center of the existing columns. The new steel was then joined to the old at five foot intervals by plates welded to the legs of the angles and to the legs of the old tees. Figures 1 and 2 show a plan and elevation of a column reinforced in this manner.

Where the six story columns were continued with new steel for the four additional stories the connections were electric arc welded as shown in Figure 3.

New elevator wells were made in the old building. In framing these in, the new steel was cut to size with a gas torch and then butt welded to the existing beams with the electric arc as shown in Figure 4. Cutting with a gas torch and fitting was due to the fact that the old beams

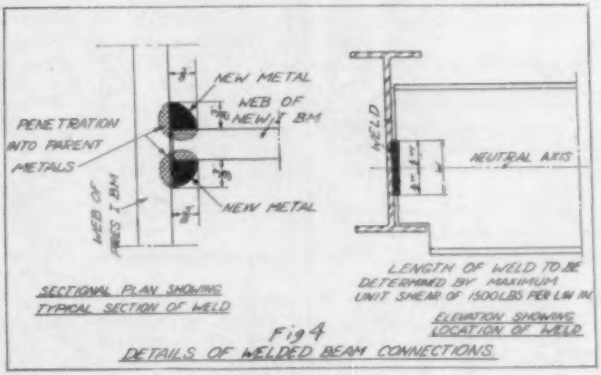

NEW METAL
WEB OF NEW I BM
PENETRATION INTO PARENT METALS
WEB OF OLD I BM
NEW METAL
SECTIONAL PLAN SHOWING TYPICAL SECTION OF WELD
WELD
NEUTRAL AXIS
LENGTH OF WELD TO BE DETERMINED BY MAXIMUM UNIT SHEAR OF 1500 LBS PER LIN IN
ELEVATION SHOWING LOCATION OF WELD

Fig 4
DETAILS OF WELDED BEAM CONNECTIONS

could not be located from the available drawings of the old structure and, as mentioned before, it was found to be more economical to cut and fit in the field rather than uncover the beams for accurate dimensions at the time structural drawings were made. Figure 5 shows arc welded connections where new beams were inserted to relieve old beam of additional load.

The beams which carried the roof of the low section of the building were not deemed to be of sufficient size to carry the seventh floor. To give them the necessary strength track rails were welded to the top flange of the existing beams as shown in Figure 6.

Welded steel bar joists are being used in the new addition. These are held in position by welding the ends of each joist to the beams. The joists are tied transversely by welding a half inch round rod to their bottom chords.

Arc welding is also being used by the plumbing contractor. Sections of 10 inch pipe which form the main steam riser are joined together by arc welding. The new process eliminates the use of threaded connections and fittings. The pipes are simply butted together and welded. Pipe joints made in this manner are tighter and resist corrosion far longer than threaded connections. This new method also is more economical when the elimination of all threading and use of fittings are taken into consideration.

The actual labor savings effected by use of arc welding in place of riveting on this project cannot be accurately estimated due to the fact

that in many instances conditions prevented the possibility of employing the traditional method of joining the steel. However, it is believed that had conditions permitted riveting, the labor cost sheets would prove that arc welding is an economical method of making field connections.

As stated before, the use of arc welding on this particular structure made it possible for the owners to obtain full revenue from their building while the alterations were in progress, as well as eliminating much

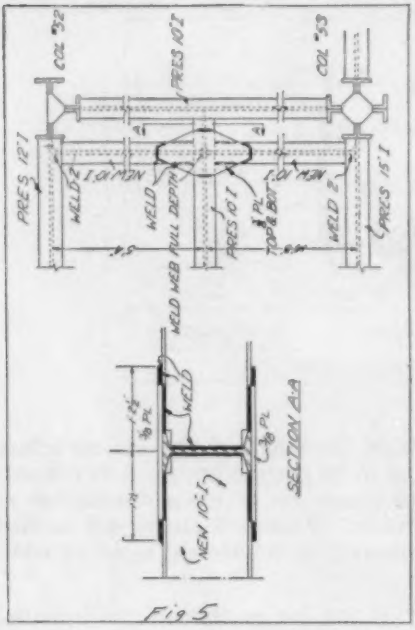
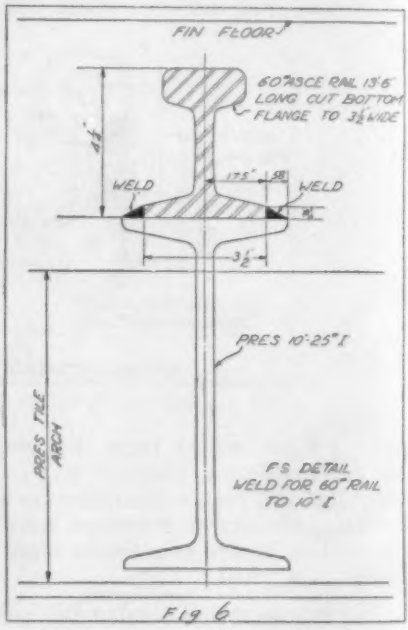


Fig 5


FIN FLOOR
60 A.S.C.E. RAIL 13'6" LONG CUT BOTTOM FLANGE TO 3½" WIDE
WELD
WELD
PRES 10·25"I
PRES TILE ARCH
F.S. DETAIL WELD FOR 60" RAIL TO 10" I
Fig 6

of the wrecking that would have been necessary to give riveters room to work while making connections to the old framework.

The Forest City Structural Steel Company were the fabricators and erectors of the structural steel for the Rose Building. Operators were required at intervals to weld samples which were tested to satisfy requirements imposed by the local building commission.

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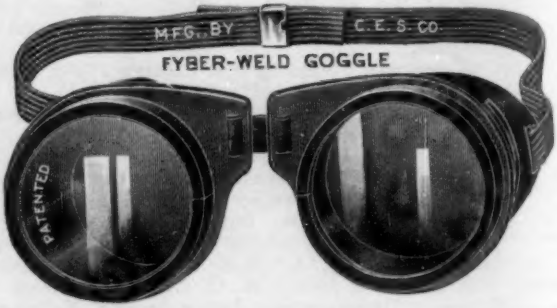


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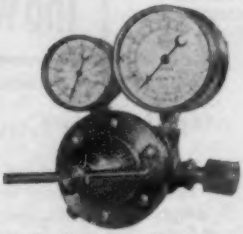
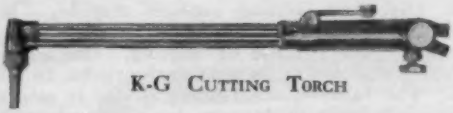


K-G OXYGEN REGULATOR

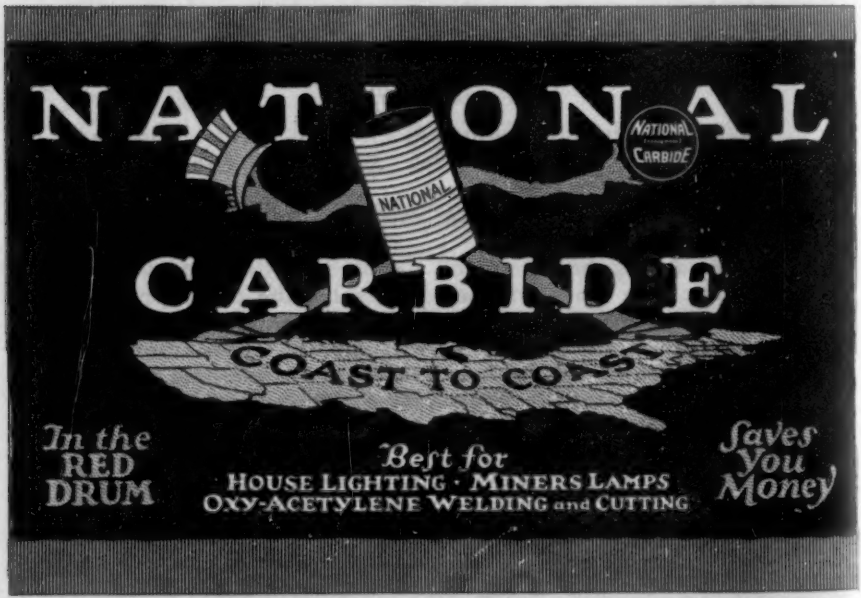


K-G CUTTING TORCH

**Gas Welding and Cutting Equipment and Supplies**

**K-G WELDING & CUTTING CO., Inc.**

**515 West 29th St. N. Y. City**




**National Carbide Sales Corporation . 342 Madison Avenue . New York, N. Y.**

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*A Grade for Every Purpose*

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We want every welder in the country—big or small—to be convinced of the *specialized superiorities* of SWEDOX products. We know that a trial *will* convince you. Hence the free offer. Try SWEDOX on your next welding job at our expense.

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*"We Ship the Same Day"*

# ACETYLENE IN PORTABLE CYLINDERS FOR OXY-ACETYLENE WELDING AND CUTTING

**Do you understand our free loan cylinder plan? If not, we are glad to explain**

*Supplied in the following size cylinders:*

**10" x 30"—capacity 125 cu. ft.**
**12" x 36"— " 225 " "**
**12" x 44"— " 275 " "**

Prompt and efficient service on any quantity through plants and warehouses and truck deliveries.

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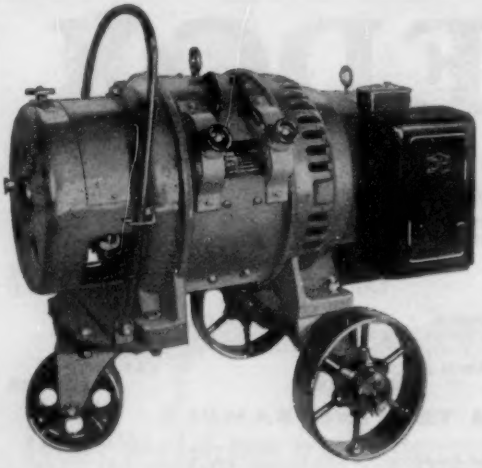

THE
FUZON
ARC WELDER

*A Welder So*
*Different*
*It Merits*
*Investigation*

FUSION WELDING CORPORATION
Engineers-Manufacturers-Merchants
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THERE IS EXCELLENCE
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Acetylene gas cuts anything—.....but
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*Our Advertisers Are Supporting the Society.*

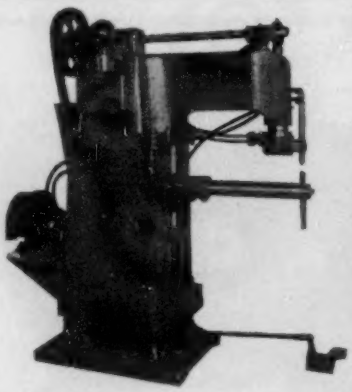
# THREE OF A KIND
## *Each a Trump Welding Set*

Many manufacturers have turned to arc welding as a means of improving their products and increasing production—accomplishing both with much saving in cost. Also, the arc is being used in the erection of structural steel work. ¶Westinghouse, anticipating the advance of welding applications, developed three entirely new welding machines. They are built to meet the requirements of modern welding—requirements which have increased with the expanding use of arc welding. The three welding sets have ratings of 200, 300 and 400 amperes with welding ranges of 60 to 300, 75 to 400 and 100 to 500 amperes respectively. ¶The design of these machines, like their operating characteristics, is strikingly new. The generators respond instantly to variations in voltage caused by changes of arc length. It is easy to strike and maintain an arc—one arc strike per length of electrode rod being common practice with these sets. ¶Write our nearest district office for Leaflets 20340-A and 20346 which give the performance and qualifications.

Westinghouse Electric & Manufacturing Company
East Pittsburgh Pennsylvania
Sales Offices in All Principal Cities of the United States and Foreign Countries

**Westinghouse**

X57165-A



# UP TO 300 SPOTS PER MINUTE—

GIBB Electric Welding Presses are automatic machines. They are built in three standard sizes. The speed of welding ranges from 60 to 300 spots per minute, depending on the gauge of stock and the size of the machine.

A particular field of application is in the more difficult and more precise welding of light to heavier parts. These machines are also ideal for welding finely polished surfaces where finish counts, such as automobile bodies, auto parts, etc. Another special application is in welding to flat surfaces, rivets, pins or any shaped rods on ends. These presses are also suitable for projection welding, making possible several welds at one time.

GIBB Welding Presses finally eliminate the uncertainty in welding the non-ferrous metals such as brass and aluminum. Utensils of these metals need no longer be riveted.

Given clean metal, these Welding Presses will weld far more securely, far more uniformly, far faster and far cleaner than has ever before been possible.

*Write for Bulletin No. 61*

**GIBB WELDING MACHINES CO., Bay City, Mich.**

*Manufacturers of*

**ARC, SPOT, SEAM, BUTT AND AUTOMATIC ELECTRIC WELDERS**

New York — Philadelphia — Cleveland — Cincinnati — Detroit — Chicago
St. Paul — St. Louis — Los Angeles — Toronto — Montreal

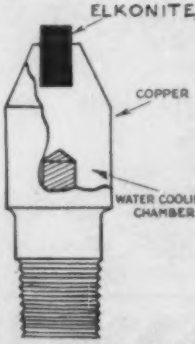



FIG. 1 WATER COOLED SPOT WELDING ELECTRODE SHOWING ELKONITE INSERT. COURTESY GENERAL ELECTRIC CO.

# Could Your Problem Be Answered By the Spot Welding of Dissimilar Metals?

The success of the use of Elkonite Welding Electrodes in spot welding dissimilar metals and alloys has brought it to the attention of welding engineers the country over.

The variable electrical and heat resistance of the different grades of Elkonite Welding Electrodes, plus their ability to hold their shape without mushrooming under red heat, heavy pressures and high currents are properties of immense value.

For this variable, relatively high resistance Elkonite as one electrode, with low resistance Elkonite or copper as the other, gives the balance necessary for even heating to welding temperature of metals of unequal heat and electrical conductivity, such as, for instance, copper with galvanized iron, or with nichrome.

This is but one phase of the contribution that Elkonite has made to resistance welding. In flash, cross-wire, projection welding, electrical upsetting of rivets, as well as in spot welding non-ferrous and heavy gauge ferrous metals Elkonite, by eliminating lost time and production due to constant redressing, and shrinkage loss, is showing new economies and production possibilities in many industries.

*Our engineering staff will gladly co-operate in any resistance welding problem.*

**Elkon Works, Inc., - Weehawken, N. J.**

*Exclusive licensees under General Electric Co. patents dated May 28, 1935 and Sept. 1, 1925. Other patents pending to Elkon Works, Inc.*

# Remarkable Adaptability *to* VARIOUS *Kinds of Welding Work*

*Wilson Model S Welding Machine, one-operator electric-motor-driven, Type 200 Amperes, welding range 10-300 amperes.*

A WELDING range of 10 to 300 amperes, rugged construction, perfect commutation, narrow frame and unusual portability give this Wilson Type 200 Amperes Model S Welder remarkable adaptability to various kinds of welding work.

Here is a machine that is adapted to a heavy current and large diameter electrodes for ***rapid depositing*** of metal, AND ALSO to a short arc with exceedingly close regulation of welding current for ***strength welding*** and repair work. Close control and quick recovery make the machine ideal for overhead welding, and it welds the thinnest sheet metal the electric arc can handle. It is equipped to give full welding range without extra apparatus or extra cost.

Other Wilson Model S Machines include one-arc gasoline-engine-driven, belt-driven or motor-driven units, and a two-arc motor-driven unit, with capacities of 10-250, 10-300, 10-600, 15-500, 15-1000 amperes. Write today for bulletins which describe all the Wilson Model S Machines.

## *Use Wilson "Color-tipt" Welding Wire*

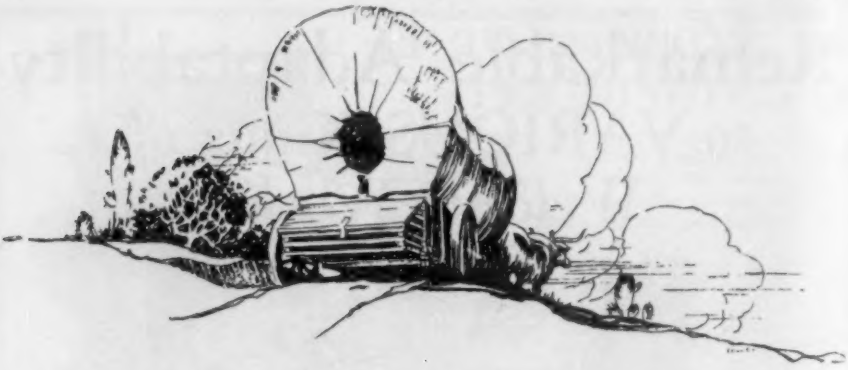
**For steel, cast iron, malleable iron, brass, bronze, copper, aluminum, Monel Metal. There is just the *right* grade (analysis) for each kind of metal—for the metal you are welding—and every grade runs *uniform throughout*. Send for samples—just indicate the metal you wish to weld.**

WILSON WELDER & METALS CO. INC., 16 WILSON BLDG., HOBOKEN, NEW JERSEY

# WILSON

## WELDING MACHINES AND WELDING WIRE

*Mention the "Journal of the American Welding Society."*



# Pioneering courage

WHEN an industry has become great, one is likely to forget that in the beginning the odds were overwhelmingly against it and that its very life depended on one thing—the courage of the men behind it.

So it is with Union Carbide. The dramatic accident of the discovery of calcium carbide, by men who later founded the Union Carbide Company, fired their imaginations with its great industrial possibilities.

Difficulties must have seemed insuperable. Yet in the face of these odds a process that would yield uniform and high quality product was developed, new uses for carbide and its child acetylene were discovered and equipment that would make these uses practical was invented.

Today, the great welding and cutting industry with its innumerable applications, the thousands of farms lighted with acetylene and the cheap and efficient mine and marine lighting systems, are a few of the things that stand as monuments to the pioneer courage that made them possible.

UNION CARBIDE SALES COMPANY
*Unit of Union Carbide and Carbon Corporation*

UCC

Carbide and Carbon Building, 30 East 42d Street, New York
Peoples Gas Building, Chicago, Ill. Balfour Bldg., San Francisco, Cal.

Why we advertise

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DISSOLVED ACETYLENE

PREST-O-LITE is a standard product—tried and proved. It has been the leader of the industry for 23 years. Its uniform high quality and country-wide delivery service are facts well-known to every user. Prest-O-Lite is readily available from

31 *Producing Plants*—102 *Warehouses*

But every day new users of the oxy-acetylene process are springing up. We want these newcomers to profit by the experience of the old-timers. And so we advertise that they may know that Prest-O-Lite is the dissolved acetylene of American industry.

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*Unit of Union Carbide and Carbon Corporation*
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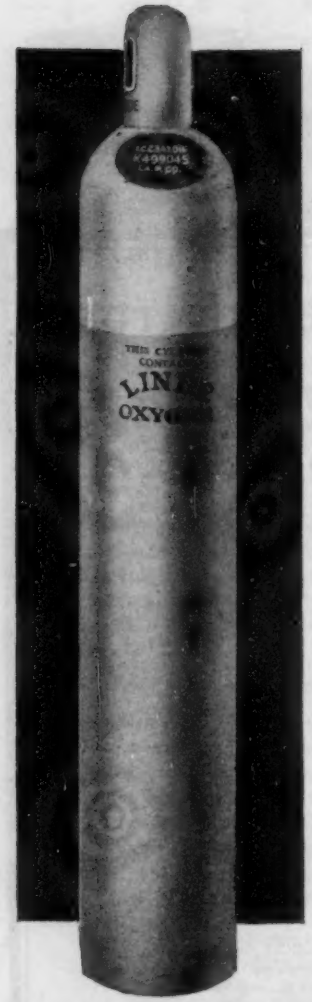
*General Offices:* Carbide and Carbon Building
30 East 42d St., New York
31 PLANTS—103 WAREHOUSES



# It isn't in the written contract

When you buy Linde Oxygen, you get not only a high grade product, the standard for more than 20 years.

And fast delivery service from the nearest of 48 plants and 105 warehouses.

But also Linde Process Service, always ready to help you get the best results in the most economical way.

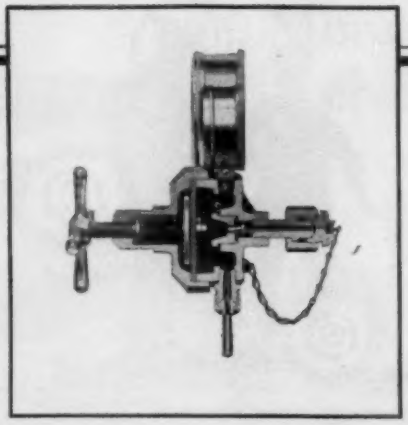
It isn't in the contract, but it goes with every cylinder.

THE LINDE AIR PRODUCTS CO.
*Unit of Union Carbide and Carbon Corporation*

49 PLANTS UCC 102 WAREHOUSES

*General Offices:* Carbide and Carbon Building
30 East 42d Street, New York

# LINDE OXYGEN



The Oxweld R-27 regulator is not a nozzle type regulator. For this reason it has exceptional flow capacity and will function properly without freezing

# Stop Playing Jackstraws *with regulator parts*

A LARGE steel company employed two men to keep their several hundred pieces of oxy-acetylene equipment in repair. Recently they standardized on the Oxweld R-27 regulator. Now one man alone is able to handle what repair work is necessary.

Why?

Because the Oxweld R-27 regulator contains only 23 parts. It does the same work older regulators did with thirty-three or more parts. In fact it does it better. Any mechanic can remove all the R-27 parts—make a thorough inspection, replacing a worn valve seat, if necessary—and reassemble—all within a very few minutes and without special tools.

This unusual simplicity in design saves hours of repair time for more productive work, and is an important factor in the most economical operation of oxy-acetylene equipment.

Oxweld
WELDING AND CUTTING APPARATUS

OXWELD ACETYLENE COMPANY
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*Unit of Union Carbide and Carbon Corporation*
NEW YORK CITY, 30 E. 42d St.
CHICAGO, Peoples Gas Bldg. SAN FRANCISCO, Adam Grant Bldg.
STOCKS IN 41 CITIES
IN CANADA, Dominion Oxygen Company, Ltd., Toronto

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# "You can't equal the Carbic for generator* portability"

IT couldn't be any simpler in construction. There are no moving parts. You can charge it in three minutes. Two men can carry it. It weighs only 200 pounds fully charged. It has unique safety features.

The initial cost is small and it is extremely economical to operate.

With a Carbic low pressure generator and a few drums of Carbic, you are always ready for any ordinary welding or cutting work.

Send for our new catalogue.

A standard drum of Carbic contains forty cakes, size No. 20. Carbic is distributed by the Union Carbide Sales Company through its national chain of warehouses

OXWELD ACETYLENE COMPANY
*Unit of Union Carbide and Carbon Corporation*
New York City, 30 East 42d St. UCC Chicago, Peoples Gas Bldg.
San Francisco, Adam Grant Bldg.

# CARBIC GENERATOR

***For Oxy-Acetylene Welding and Cutting***

*•Anyone having a Carbic Generator is entitled to Oxweld Generator Service. Phone or write our nearest district office.*

Gate valve which had been scrapped. Tobin Bronze welded and returned to service.

# Money *Saved* by Repair-Welding Broken Parts *with* TOBIN BRONZE

Reg. U. S. Pat. Off.

THE gate valve illustrated was consigned to the scrap heap as the available means for making repairs were considered too costly and the results questionable.

An experienced welder who happened to be in the plant saw the valve and reported that he could Tobin Bronze Weld it at a nominal cost.

The cast iron body of the valve which was cracked clear around was welded with Tobin Bronze by the oxy-acetylene process without special pre-heating. It was returned to service as good as new, at a fraction of its original cost.

Many manufacturers are saving money by repair-welding broken parts with Tobin Bronze. Other concerns are using Tobin Bronze Welding to improve the quality of manufactured products and to reduce production costs. Tobin Bronze Welding Rods may be obtained from distributors of welding equipment and supplies. The name "Tobin Bronze" is stamped in every rod.

THE AMERICAN BRASS COMPANY
GENERAL OFFICES: WATERBURY, CONN.
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New Toronto, Ontario

ANACONDA
COPPER ANACONDA BRASS

ANACONDA
from mine to consumer

*There is a suitable Anaconda Filler Rod for every welding purpose. The principal Anaconda Welding Rods, with their melting points, are listed below:*

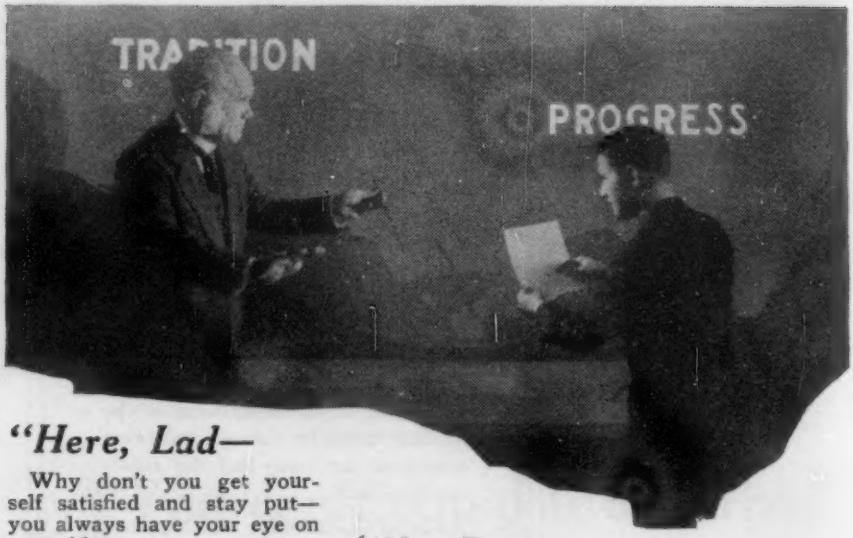
*for oxy-acetylene welding*

| | |
|---|---|
| Tobin Bronze | 1625°F |
| Manganese Bronze | 1598°F |
| Brazing Metal | 1614°F |
| Deoxidized Copper | 1981°F |
| Electrolytic Copper | 1981°F |
| A. B. Nickel | 1625°F |
| Everdur | 1866°F |
| Ambrac | 2102°F |

*for arc welding*

| | |
|---|---|
| Phosphor Bronze | 1922°F |
| Everdur | 1866°F |
| Ambrac | 2102°F |
| Deoxidized Copper | 1981°F |

**Pop learns when to progress**




*"Here, Lad—*

Why don't you get yourself satisfied and stay put—you always have your eye on new things.

First you wanted me to take up arc welding—so I did.

Then you wanted better machines—so we put in Lincoln 'Stable-Arcs.'

Now when we have the best welders (machines and men)—you come along and want us to TRY some NEW welding rod."

*"No, Pop—*

I didn't say TRY—I said BUY

—and I didn't say NEW—I said BLUE (Lincoln 'Stable-Arc' Blue)

—and I never keep my eye on new things. I let the other fellow do that, and I keep my eye on HIM.

And when he strikes a rich vein, I start digging.

'Stable-Arc' BLUE welding rod (non-splashing) has been TRIED.

So now it is a tried-and-TRUE rod—TRUE BLUE as it were."

A new textbook on Arc Welding (Price $1.50) will be sent on approval for five days to any executive requesting it.

Book size, 6" x 9" — total pages, 160—number of illustrations, 200 — Charts, 62 — Divisions, 8.

The Lincoln Electric Co., Dept. No. 22-7, Cleveland, Ohio

W-41

"Stable-Arc" LINCOLN WELDER

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*Mention the "Journal of the American Welding Society."*




# Roebling

IN the large important steel works; shipyards; industrial plants; mines; automobile shops; railroad shops and repair shops Roebling Welding Wire is demonstrating its efficiency and reliability. Roebling Electrodes are positively uniform throughout the same shipment and throughout all shipments.

John A. Roebling's Sons Company
Trenton, New Jersey

*Mention the "Journal of the American Welding Society."*

The More
One of twelve 25,000-kv-a. power transformers completely arc welded for a single order. Each transformer stands 27 feet, 4 inches high and required 692 lineal feet of arc welding
One of the new all-welded factory buildings at the G-E West Philadelphia plant. 1000 tons of structural steel noiselessly welded by the electric arc—a striking example of the trend in building construction
Arc welding the tank unit of the G-E electric refrigerator with the enclosed G-E atomic hydrogen process
Hub stator frame of a turbine-driven generator, completely arc welded
THE MORE YOU ARC WELD
THE MORE YOU SAVE
GENERAL
GENERAL ELECTRIC COMPANY, SCHENECTADY, N. Y.

# We ARC WELD—

# The More We Save!

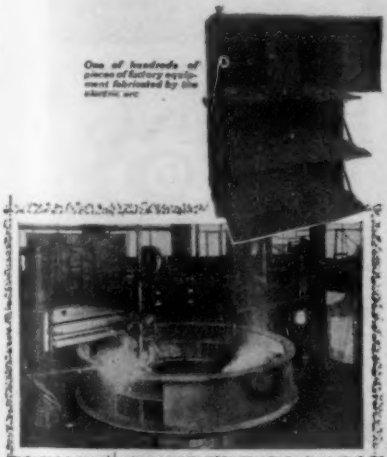
General Electric is the world's largest user of arc welding and is constantly discovering new applications for it both as a production tool and as a repair tool.

Arc welding has made G-E equipment lighter yet stronger—simpler, more enduring, and more attractive. It has eliminated costly manufacturing processes all along the line from drafting room to finished products. And it has materially decreased the outlay for manufacturing tools.

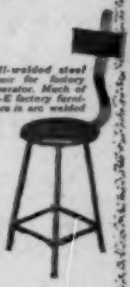
Nothing "will-o'-the-wisp" about these savings! They are impressive and they have enabled General Electric to improve its products continually and to reduce its prices substantially.

Arc welding has reached the point where it demands your immediate attention. It is radically changing manufacturing methods. Be the first in your field to use it—and reap the rewards of the successful pioneer. Your nearest G-E office will give you valuable help in applying arc welding in your plant.

Arc welding is also one of the most important repair tools used in G-E Service Shops. The use of this modern tool has been largely responsible for the fast, low-cost, and superior repair jobs which are a tradition with all G-E Service Shops.



One of hundreds of pieces of factory equipment fabricated by the electric arc



All-welded steel chair for factory operator. Much of G-E factory furniture is arc welded

Welding the stator frame of a 40,000-kw. generator for the Conowingo Power Development. The frame is 37 feet in diameter, and all circular seams are automatically welded

Two-head automatic arc welding machine welding a 14-ft. stator frame

530-41D

# GENERAL ELECTRIC

SALES OFFICES IN PRINCIPAL CITIES

## Just Turn The Tip to Change From Cutting to Welding

**The Same Torch and the Same Tips for Both Operations**

Here's another Milburn time, labor and money saver. One torch and one set of tips for cutting and welding. A quarter turn of the tip makes this cutting torch a welding torch and vice versa. This remarkable new torch, known as the Type TI, saves expense of one Torch; saves expense of extra tips; saves operators' time and saves gases usually lost when changing torches. In addition, it employs Milburn principles which have caused users of Milburn Torches to report operating savings of 20% and upwards. Cuts metal up to 10" thick and performs all welding within range of the process. Get full details of this remarkable Milburn invention.

*Ask for Booklet* 3547.

If interested in Generators, Regulators, Carbide Lights or Paint Spray Equipment, ask for details of these also.

**THE ALEXANDER MILBURN COMPANY**
**1416-1428 W. Baltimore St. Baltimore, Md.**

*If You Want to Know Why*

REGO

OXY-ACETYLENE EQUIPMENT

Gives more satisfactory service. Operates with a lower gas cost. Costs less to maintain *than any other equipment—*

*Write for Booklet* - "FACTS"

THE BASTIAN-BLESSING CO.
252 E. Ontario St. Chicago

# THERMIT WELDING

***Proven, inexpensive, practical, and simple in its application to all classes of work involving the repair of medium and heavy size sections of iron and steel.***

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*Railway*
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**120 Broadway, New York, N. Y.**
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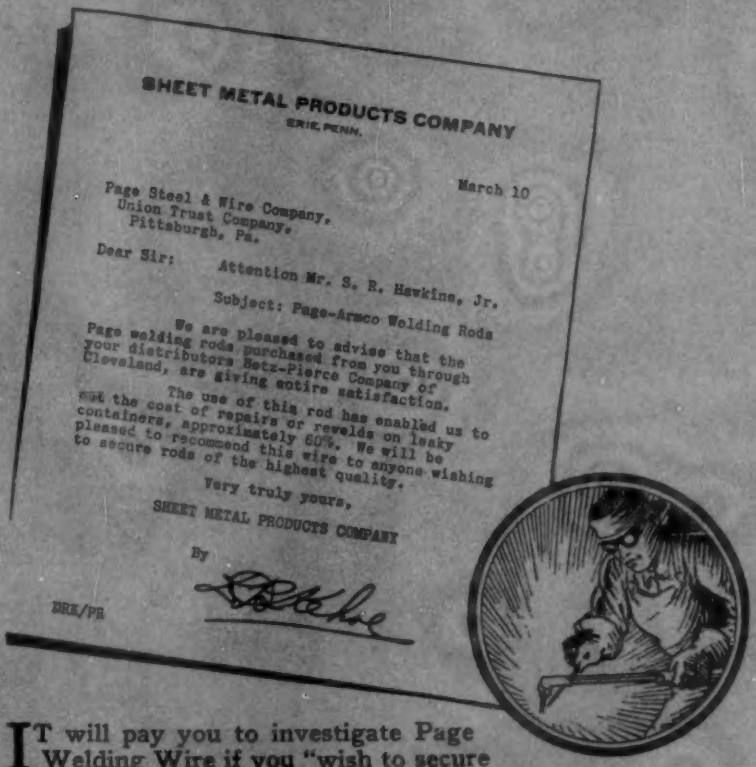
# "...This rod has enabled us to cut cost of repairs approximately 60%"



SHEET METAL PRODUCTS COMPANY
ERIE, PENN.

March 10

Page Steel & Wire Company,
Union Trust Company,
Pittsburgh, Pa.

Dear Sir:

Attention Mr. S. R. Hawkins, Jr.

Subject: Page-Armco Welding Rods

We are pleased to advise that the Page welding rods purchased from you through your distributors Betz-Pierce Company of Cleveland, are giving entire satisfaction.

The use of this rod has enabled us to cut the cost of repairs or rewelds on leaky containers, approximately 60%. We will be pleased to recommend this wire to anyone wishing to secure rods of the highest quality.

Very truly yours,

SHEET METAL PRODUCTS COMPANY

By

DRK/PE

IT will pay you to investigate Page Welding Wire if you "wish to secure rods of the highest quality." Your name and address will bring "Page Welding Wire Hand Book" and a sample of Page Welding Wire.

## PAGE STEEL *and* WIRE COMPANY

**Bridgeport, Connecticut**

*District Offices:*
Chicago, New York, Pittsburgh, San Francisco
An Associate Company of the American Chain Company, Incorporated
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# PAGE-ARMCO
## PROCESSED
# Welding Wire *and* Electrodes

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